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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CX.—No. 2848.] [*Registered at the General Post Office as a Newspaper.*] *LONDON: FRIDAY, JULY 30, 1920.* [DOUBLE NUMBER WITH INDEX. PRICE...2s. 4d. BY FOREIGN POST ... 2s. 5d.

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See Advertisement page 124. 8187

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for Chemical Wks., Mineral Water Mfrs., Breweries, and all other purposes.—SPARKLETS AND GENERAL MFG. CO., Ltd., Edmonton, London, N. 18. 7895

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Yarrow Patent Water-tube Boilers. 8709
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Matthew Paul & Co., Ltd. Dumbarton. 8658
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See Full Page Advt., page 93, July 23.

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Forgings, Castings, Bars, Sheets, Wire, Tubes.
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8196
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See Full Page Advertisement, July 23.

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See half-page Advert. last week and next week. 8460

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See half-page Advertisement page 137, July 9.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

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Founded 1854 by SIR WILLIAM FAIRBAIRN.

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Royal School of Mines FERCHEVILLE RESEARCH FELLOWSHIPS.

THE IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, South Kensington, London, S.W. 7, with which the Royal School of Mines is incorporated, is OFFERING TWO RESEARCH FELLOWSHIPS of £300 a year each, tenable for one year, and possibly renewable for a second year, to aid in carrying out any investigation or research connected with Mining, Mining Geology, Metallurgy, or the Technology of Oil, which, in the opinion of the Selection Committee, is of sufficient use or promise.

Applicants, who may be Associates of the Royal School of Mines, or others, and preferably men with some practical experience, should apply, in writing, to the SECRETARY of the COLLEGE (from whom further particulars may be obtained), before 1st September, 1920, giving the nature of the proposed investigation, qualifications for the work and references.

It is anticipated that the Committee will make the awards by the end of November, so that the Fellowships and work may begin on 1st January, 1921. Holders will be expected to devote their whole time to the work, which may be conducted at the Imperial College or in special circumstances elsewhere at the discretion of the Committee. H 510

PATENTS AND DESIGNS ACTS, 1907 AND 1919.

Notice is Hereby Given that

JOHN OLIVER ARNOLD, of 6, Beach Hill Road, City of Sheffield, seeks leave to amend the Specification of Letters Patent No. 137083 granted to him for "Improvements in High Speed Steel."

Particulars of the proposed amendment were set forth in the *Illustrated Official Journal (Patents)*, issued on the 21st July, 1920.

Any person, or persons, may give notice of Opposition to the Amendment by leaving Patents Form No. 19, at the Patent Office, 25, Southampton Buildings, London, W.C. 2, within one calendar month from the date of the said Journal.

W. TEMPLE FRANKS, Comptroller-General.

Agents: R. F. DRURY & SONS, Registered Patent Agents, Sheffield. H 906

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successes by Correspondence Coaching. Several prizes. Sec. "O" now prepared. (Designs, Specifications and Quantities). A few vacancies open.—Address, 7424, Offices of ENGINEERING.

Correspondence Courses for

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Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., Assoc. M. Inst. C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes. Courses may commence at any time.—39, Victoria St., Westminster, S.W. S632

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Marine & Aero-Engines, Alternating Currents, Wireless Course, Ferro-Concrete, Refrigeration, Pract. Maths. and Calculus.—PENNINGTONS, University Tutors, 254, Oxford Rd., Manchester.

TENDERS.

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD (PLANT AND MACHINERY SECTION).

For Sale by Public Tender.

SECOND-HAND 4—8½ GAUGE WAGONS.

22 Four-wheeled 8 ton WAGONS, mostly high sided; six with spring buffers and the remainder with dead buffers.

Lying at Admiralty Mining Depot, Aintree.

150 Four-wheeled 8 ton WAGONS, sides 3 ft. 9 in. high, spring buffers; approximately 8½' steel underframes and remainder wood underframes.

Lying at Admiralty Mining Depot, Grangemouth.

88 Four-wheeled (high and low sided) WAGONS, loads not indicated but presumably are 8 ton, with wood underframes and spring buffers

Lying at Admiralty Mining Depot, Glen Albyn, Inverness.

One Old BRAKE VAN, six-wheeled, three compartments, by Midland Railway & Carriage Co.

Four Old Five-compartment PASSENGER COACHES, by L. & S.W.Ry.; six-wheeled.

Permits to view and Tender Forms may be obtained on application to the CONTROLLER, D.B.I.(E), Plant and Machinery Section, Charing Cross Huts, Embankment, W.C. 2.

Tenders to be returned not later than Ten a.m., August 23rd, 1920.

NOTE.—For particulars of other Government Property for Sale see *Surplus*, price 3d. at all bookstalls; or by quarterly subscription of 2s. post free in the United Kingdom, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. H 905

PORT OF BRISTOL.

EXTENSION OF GRANARY, ROYAL EDWARD DOCK, AVONMOUTH.

The Docks Committee are prepared to receive

Tenders for the Construction

of a FERRO-CONCRETE BUILT SILO GRANARY of 20,000 tons capacity, carried on Ferro-concrete Piles.

On and after Wednesday, the 4th August, 1920, copies of the Specification and Contract Drawings can be obtained from the undersigned on production of a receipt shewing a deposit of £5 has been paid to the SECRETARY of the Docks Committee, at 19, Queen Square, Bristol, to whom all cheques must be made payable. The deposit of £5 will be returned to all bona fide Tenderers after the receipt of a Tender with all the prescribed documents and drawings.

Tenders must be enclosed in a sealed envelope, endorsed "Tender for Extension of Granary," and addressed to the SECRETARY of the Docks Committee, 19, Queen Square, Bristol, and must be delivered to him accompanied by all the prescribed documents and drawings before Ten a.m., on Friday, the 27th August, 1920. The Docks Committee do not bind themselves to accept the lowest or any Tender.

THOMAS A. PHACE, Engineer's Office, Engineer.
Avonmouth Dock.
17th July, 1920. H 885

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD (PLANT AND MACHINERY SECTION.)

For Sale by Public Tender.

At THE R.A.F. STATION, GREAT YARMOUTH, Considerable QUANTITY of High-class MACHINE TOOLS and PLANT, including Lathes, Grinding Machines, Drilling Machines, Milling Machines, Shapers, etc., etc., by the best makers; also TIN PLATE PLANT, WOOD-WORKING PLANT, Blacksmiths' and Coppersmiths' HEARTHS, etc.

Full particulars of plant together with tender form and permits to view may be obtained on application to the CONTROLLER, D.B.I.(E), Charing Cross Embankment Huts, London, S.W. 1.

All Tenders to be received by TEN a.m., August 6th.

NOTE.—For particulars of other Government Property for Sale, see *Surplus*, price 3d. at all Bookstalls; or by quarterly subscription of 2s. post free in the United Kingdom, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. H 913

THE HIGH COMMISSIONER FOR NEW ZEALAND is prepared to receive

Tenders from Loco-

motive Builders, Wagon Builders, Wheel and Axle, and Spring Makers who are in a Position to Supply within 12 months from date of contract:—

25 TENDER LOCOMOTIVES (4-6-2 type) to the New Zealand Government Standard design.

2500 STEEL OPEN HIGH SIDED RAILWAY WAGONS, without Wheels and Axles or Springs.

2500 SETS OF WHEELS with Tyres and Axles for the above wagons.

2500 SETS OF BEARING AND DRAWBAR SPRINGS for the above Wagons.

The Conditions of Contract and Form of Tender may be obtained on application to the High Commissioner for New Zealand, 415, Strand, London, W.C. 2, and the detail drawings may be seen at the offices of the Consulting Engineer, Sir J. DUNCAN ELLIOT, 13, Victoria Street, S.W. 1.

Tenders are to be delivered at the Office of the HIGH COMMISSIONER for NEW ZEALAND by Noon on August 25th, 1920, for the Locomotives, and on August 18th for the Wagons, Wheels and Axles, and Springs, after which time no Tender will be received.

The High Commissioner for New Zealand does not bind himself to accept the lowest or any Tender, or to defray any expenses in connection with tendering.

A deposit to cover the cost of the specifications may be required, which will be returned on receipt of a *bona fide* Tender. J 33

TYNE IMPROVEMENT COMMISSION.

DREDGER AND WOOD HOPPERS FOR SALE.

The Tyne Improvement Commissioners invite

Tenders for the Purchase, as

they lie, exclusive of Mooring Chains and Ropes, of the undermentioned VESSELS, viz.:—

No. 2 Twin Screw Double Outside Ladder BUCKET DREDGER, of approximately the following dimensions:—Length 92 ft., breadth 29 ft. 6 in., depth 12 ft. 6 in. The Dredger, which has an iron hull, is fitted with two single engines, two boilers, and complement of buckets for each ladder. There is also a large assortment of spare gear, including top and bottom tumblers, links, buckets, spouts, etc., stored at the Tyne Improvement Commissioners' Yard, Howdon-on-Tyne.

WOOD HOPPERS Nos. 16, 18 and 34. The dimensions of these Hoppers are as follows:—

	Length.	Breadth.	Depth.
No. 16 Hopper	80 ft. 6 in.	27 ft. 0 in.	11 ft. 9 in.
No. 18 ,,	80 ft. 6 in.	27 ft. 0 in.	12 ft. 3 in.
No. 34 ,,	93 ft. 6 in.	28 ft. 2 in.	11 ft. 9 in.

The vessels may be inspected on application to the MANAGER, at the Commissioners' Yard, Howdon-on-Tyne.

Full particulars and Conditions of Sale can be had on application to the undersigned, to whom Tenders, endorsed on the cover "Tender for Dredger and Hoppers," must be delivered not later than Twelve o'clock noon, on Wednesday, the 4th August, 1920.

The Commissioners do not bind themselves to accept the highest or any Tender.

By Order,
J. McD. MANSON,
General Manager and Secretary.

Tyne Improvement Commission Offices,
Bewick Street,
Newcastle-upon-Tyne.
26th July, 1920. H 978

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD. (PLANT AND MACHINERY SECTION.)

For Sale by Public Tender.

Lying at Messrs. BEARDMORE & Co., PARKHEAD, GLASGOW.

19 High-Class 21in. Centre SS. and Sc. LATHES, maximum distance between centres 22 ft. and 26 ft., each with 4-Speed Gear Box, 2 Duplex Saddles with front and back tool rests, 3 point stay, 19 change wheels, also 30 HP., Motor and control panel for driving same.

Two Patent High Speed PLANING MACHINES to plane 6 ft. wide, 6 ft. high and 16 ft. long, electrically driven by patent Lancashire drive, each with the necessary switch gear.

Three SURFACE TABLES, 20 ft. x 8 ft.

Three BELT DRIVEN MILLING and PROFILING MACHINES, by Smith of Coventry.

Two BAND SAWING MACHINES by Noble & Lund, electrically driven and control panel for same.

Full particulars, etc., including tender forms and permits to view, may be obtained on application to the CONTROLLER, D.B.I. (E), Charing Cross Embankment Huts, London, S.W. 1.

All Tenders to be received by TEN a.m., August 6th.

NOTE.—For particulars of other Government Property for Sale, see *Surplus*, price 3d. at all Bookstalls, or by quarterly subscription of 2s. post free in the United Kingdom, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. H 912

APPOINTMENTS OPEN.

THE UNIVERSITY COLLEGE OF SOUTHAMPTON.

LECTURER IN ENGINEERING.

Applications are Invited for

the above POST at a salary of £350 to £400 per annum according to qualifications.

Further particulars may be obtained from the REGISTRAR. H 889

BIRMINGHAM MUNICIPAL TECHNICAL SCHOOL.

Required, in September next,

the Full-time Services of a LECTURER in METALLURGY.

The commencing salary offered will depend upon the previous training and experience of the candidate.—For full particulars, apply to the SECRETARY, Municipal Technical School, Suffolk Street, Birmingham. J 38

THE ROYAL TECHNICAL COLLEGE, GLASGOW.

DEPARTMENT OF MECHANICS.

Applications are Invited for

TWO ASSISTANT LECTURESHIPS in MECHANICS. Candidates must have had a thorough theoretical and practical training in Engineering and experience in Materials Testing and Hydraulics Laboratories. Duties will commence on 1st September. Salaries £240 per annum.

Applications should be addressed to the PROFESSOR OF MECHANICS, The Royal Technical College, Glasgow. J 4

UNIVERSITY COLLEGE OF SOUTH WALES AND MONMOUTHSHIRE.

COLEG PRIFATHROFAOL DDEHEUDIR CYMRU A MYNWY.

The Council of the College invites

Applications for the Post of

ASSISTANT LECTURER and DEMONSTRATOR in ENGINEERING. Salary £250, increasing to £300 per annum.

Further particulars may be obtained from the undersigned, by whom applications and testimonials (which need not be printed) must be received on or before August 7th, 1920.

D. J. A. BROWN, Registrar.
University College, Cardiff,
July 27th, 1920. J 35

COUNTY BOROUGH OF BARROW-IN-FURNESS.

TECHNICAL AND JUNIOR TECHNICAL SCHOOLS.

Principal - D. HARDMAN, M.Sc.

Applications are Invited for

the POST of TEACHER of ENGINEERING SUBJECTS (Graduate or equivalent qualifications). Salary—Min. £300, Max. (according to Scale) £450. Commencing salary based on experience and qualifications.

Further particulars may be obtained from the DIRECTOR OF EDUCATION, Town Hall, to whom applications should be forwarded on or before 14th August, 1920.

By Order,
L. HEWLETT,
Town Clerk and Clerk to the Local
Town Hall, Education Authority.
27th July, 1920. J 36

MUNICIPAL TECHNICAL SCHOOL, LONDONDERRY.

The Technical Instruction

Committee REQUIRE the SERVICES of a TEACHER of MECHANICAL ENGINEERING SUBJECTS, to commence duties on September 1st, 1920. Salary £180 per annum, together with War Bonus—at present £178 per annum.

Forms of application may be obtained from the PRINCIPAL at the School, and must be returned before Saturday, August 7th, 1920.

J. A. WILLIAMS, Secretary.
J 14

THE UNIVERSITY OF LIVERPOOL.

GRADE III., LECTURESHIP IN ENGINEERING DESIGN AND DRAWING.

The Council invite

Applications for this Post.

Salary £300, increasing to £400 by annual increments of £50. — Full particulars may be obtained from the REGISTRAR, to whom applications must be made on or before September 1st, 1920. H 973

WIGAN AND DISTRICT MINING AND TECHNICAL COLLEGE.

Applications are Invited for

the POST of LECTURER in MECHANICAL ENGINEERING.

Salary £400.

Particulars may be had from the PRINCIPAL, to whom applications should be addressed as early as possible.

Enquiries and applications should have envelopes endorsed "Appointment." J 10

THE TECHNICAL COLLEGE, LOUGHBOROUGH.

H. SCHOFIELD, M.E.H., B.Sc. (Lond.), A.R.C.Sc. (Lond.), A.M.I.C.E., D.I.C., Principal.

Wanted, for the Commence-

ment of the Autumn Term, a LECTURER in MATHEMATICS for the Senior College.

Applicants should be graduates of a British University, and previous teaching experience is desirable.

Commencing salary £300 per annum, with suitable increments upon satisfactory service.

Applications must be submitted to the PRINCIPAL of the College on the prescribed form, which may be obtained from him.

The latest date for receiving applications is Thursday, 26th August, 1920. H 966

PORTSMOUTH MUNICIPAL COLLEGE.

Principal: OLIVER FREEMAN, Wh. Sc., A.R.C.S., B.Sc.

Applications are Invited for

the following APPOINTMENTS:—

HEAD OF MECHANICAL AND CIVIL ENGINEERING DEPARTMENT. Salary £450.

LECTURER IN ELECTRICAL ENGINEERING. Present maximum salary £350, commencing according to qualifications and experience of candidate.

Application Forms and further particulars may be obtained from the undersigned, to whom applications should be returned as early as possible, accompanied by copies of not more than three recent testimonials.

H. E. CURTIS, Secretary.

Offices for Higher Education,
Municipal College,
Portsmouth. J 20

ROYAL AIR FORCE SCHOOLS OF TECHNICAL TRAINING (BOYS).

Applications are Invited

for a number of VACANCIES in GRADE III. (ASSISTANT MASTERS), on the Civilian Educational Staff of the Schools for Boy Mechanics, at the undermentioned Royal Air Force Stations:—

Cranwell, near Sleaford, Lincs.
Halton, near Wendover, Bucks.

The subjects of instruction include Practical Mathematics, Applied Mechanics, General Physics, Drawing and English (language, literature, geography, history and civics).

Candidates must possess a University degree or equivalent qualification, and will be required to teach either (i) Mathematics and Science, or (ii) English, preferably with Mathematics or Science as a subsidiary subject.

The salary scales, to which the full Civil Service bonus will be added, are as follows:—

	Basic scale.	Approximate rate with current bonus. (Subject to variation.)
Grade I. Headmaster	£450-£30-£550	£787 to £904
,, II. Senior Master	£350-£10-£300 £15-£450	£464 to £787
,, III. Assistant Master	£150-£10-£200 £15-£350	£308 to £611

In fixing the initial rates of salary in appointments to Grade III., allowance may be made for previous experience of a suitable character up to a maximum of 10 years (10 increments of the scale).

For those who complete three or more years of service there will be a scheme of deferred pay in lieu of pension.

Forms of application with further particulars can be obtained on application to the SECRETARY (T.2.b.), AIR MINISTRY, Kingsway, W.C. 2. H 969

Sales Manager Required in

London to handle output of Engineering firm in Midlands specialising in Colliery Plant, Coalcutters, etc., and general engineering. Full particulars, age, experience, salary asked, etc.—Address, H 968, Offices of ENGINEERING.

Wanted, London, E.C.,

GENTLEMAN to be trained through successive stages as Works Manager, a position which must be occupied within a few years. Must be good all round Mechanical Engineer, about 30 years of age. Board of Trade Certificate. Good workshop experience, able to handle modern workmen. Organiser, and experienced in Oil Engines. Until salaried position is attained, remuneration will be £6 10s. per week. Probable superannuation. Copies of Testimonials only.—Address, J 15, Offices of ENGINEERING.

Control Room Attendant Re-

QUIRED for Power House at Large Industrial Works in the Midlands. Must have had experience in R.H.T., 3 phase system, and remote control switch gear. Wage £4 15s. per week.—Address, J 38, Offices of ENGINEERING.

THE INSTITUTION OF MECHANICAL ENGINEERS.

(*Concluded from page* 122.)

THE Lincoln meeting of the Institution of Mechanical Engineers was continued on Wednesday, July 21, when members assembled at 10 a.m. in the Municipal Technical School, for the reading and discussion of several papers. The President, Captain H. R. Sankey, occupied the chair.

SOME LINCOLNSHIRE OIL ENGINES.

The first paper to be taken was one by Mr. F. H. Livens, entitled "Some Lincolnshire Oil Engines." It was dealt with in abstract by the author who remarked that one of the latest types of Ruston engines had been tested lately by Captain H. R. Sankey. Fig. 1, annexed, shows the curves for this test which, as Captain Sankey explained, gave the results of a trial extending from 8 a.m. to 6.30 p.m., during which time the engine ran perfectly. The observation points were at full load, three-quarter, half, quarter, and no load; and finally the engine was run at overload. The middle points would be seen to be on a straight line which was in accordance with the well-known Willans Law. At no load and overload the points were just above the straight line. The best consumption was at 220 brake horse-power when the engine used 0·4 lb. per brake horse-power, the fuel being an Anglo-American quality of treacley oil of which the calorific value would probably be about 18,100 British thermal units; the exact figure had not yet been ascertained. Fig. 2 showed the results of another trial made 13 years ago by Captain Sankey on a Willans-Diesel engine. Again the middle points were on the straight line and the curve went up at no load and overload. In this case the no load point was obtained by inference; it was not actually taken, as it had been in his recent test. According to his deduction the no-load consumption had been 19 per cent. of that at full load. This Willans-Diesel engine had shown its best economy at full load, when it amounted to 0·45 lb. per brake horse-power, or $\frac{1}{100}$ lb. more than in the recent type of Ruston engine. Some years ago, Captain Sankey said, he had prophesied that the so-called Diesel engine would be replaced by an engine of this type, and he now thought his prophesy was coming true.

Mr. Livens further supplemented his paper by the diagram shown in Fig. 3. This showed, in the first place, a Diesel engine diagram taken from Lt. Wilkins' paper published in the Proceedings of the Institution for October, 1916 (page 594). This diagram disproved absolutely Diesel's claim that his cycle included constant temperature during combustion. There was an increase of no less than 600 deg. C., between the commencement and completion of the fuel ignition. A comparative Ruston card was shown; the card gave the same initial pressure. The expansion curve was lower, and he believed it would be proved that the actual cycle realised Diesel's claim more nearly than did Diesel's own engine.

In proposing a vote of thanks to the author, the President said the paper professed to be an account of some Lincolnshire oil engines; actually it was a history of the British oil engine. The diagrams and figures indicating the changes in economy deserved attention. The first series of diagrams of the paper showed the Akroyd cycle, in which air was compressed and oil added at the end of the stroke. This was the Diesel system, and, therefore, the latter should rightly be named the Akroyd system. The main Diesel claim could be shown to be an impossible one; it was not possible to have constant temperature and constant pressure at the same time. The Diesel engine of to-day did not conform to the claims covering Diesel's invention, and the Institution ought to foster the idea of the name of the Akroyd engine in lieu of it.

The first speaker in the discussion was Mr. Tookey, who said the paper was exceedingly good. There were very few papers on the subject in the Proceedings of the Institution, though it was one which would bear several. There were still a number of points to settle. The author had touched lightly on the many improvements that had been made, but he had not said anything about the troubles which formerly were numerous. The old type of vaporiser, for instance, had its defects. Telegrams used to come in "Send at once," &c., and they would often find that all that wanted to be done was the cleaning of the vaporiser and valves. Those defects were gradually being overcome in the later designs, and particularly, he thought, in the latest type referred to in the paper. He also had made a trial of this type. He found the engine started on air without the least trouble, and without any previous preparation. It had been run side by side with a 1909 type of the same power. The dynamos were coupled to the same bus bars and the load equally divided between the two engines.

Fig. 1. FUEL CONSUMPTION CURVES OF RUSTON HIGH COMPRESSION OIL ENGINE. TEST MADE JULY 13 1920. ANGLO-AMERICAN FUEL OIL. 260 H.P. TWIN CYL. ENGINE.

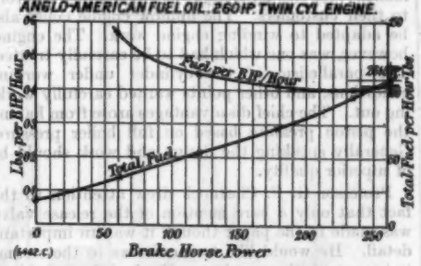


Fig. 2. TEST OF 225 B.H.P. THREE-THROW DIESEL ENGINE. WILLANS AND ROBINSON. 196 R.P.M.

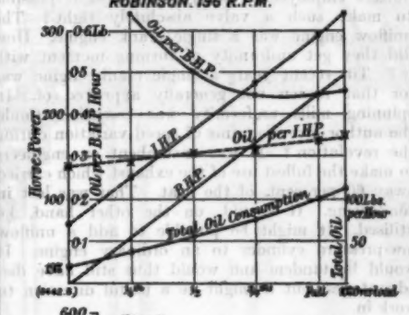
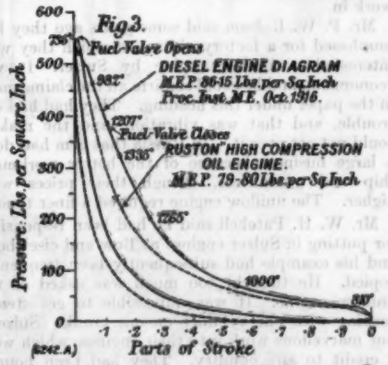


Fig. 3.


Fuel Valve Opens
DIESEL ENGINE DIAGRAM
M.E.P. 86·45 Lbs. per Sq. Inch
Proc. Inst. M.E. Oct. 1916.
Fuel Valve Closes
"RUSTON" HIGH COMPRESSION OIL ENGINE.
M.E.P. 79-80 Lbs. per Sq. Inch
Pressure. Lbs. per Square Inch
Parts of Stroke
(5242.A)

The result of the working showed that there was now no trouble in maintaining the higher thermal efficiency over longer periods. The oil consumption was good, and for the 1915 engine was only 18 gallons per day, which was two-thirds of that used by the 1909 engine. That could be maintained in every-day work. The author had not hinted about the future. He asked whether the author's experience was indicated by the fact that he had not put forward a two-cycle design. That type had advantages as well as disadvantages. He thought war experience indicated that they might with advantage go in for slightly higher speeds. The tank, and other engines were types of high-powered engines in a small space, due to the adoption of a higher speed. They might move in that direction with advantage.

Mr. W. T. Bell said that on the question of the two-cycle engine people would have to agree to differ. Simplicity was often a decisive advantage when it came to placing engines in unskilled hands.

Mr. S. G. Martlew asked whether the author had adopted any recognised procedure with regard to the annealing of connecting-rod bolts. Also, what period of working did he advise between taking down valves, &c., for cleaning?

Mr. J. V. Coonan said he considered that Diesel had no claim at all, and Diesel's patent was anticipated in England.

Mr. L. St. L. Pendred asked whether it was due to our magnanimity or our folly that we always brought foreigners to the fore. He had lately protested at the Institution against the Michell bearing being given the American name of the Kingsbury bearing. The Uniflow engine was British, but it was not till it came back to this country from Germany under the name of the Stumpf engine that we took any notice of it. The Diesel engine was properly the Akroyd-Stuart engine which was worked long before the Diesel patent. Diesel drew in and compressed pure air in the cylinder and then blew oil at a higher pressure into it. The system involved the use of a compressor to obtain this necessary higher pressure. The Akroyd-Stuart system needed no compressor, and, therefore, abolished these troubles, and complications. The term Diesel must still be used for engines using oil injection by a compressor. The term semi-Diesel should most certainly be jettisoned, and he proposed that the name of Akroyd be given to the system.

The President said the Ruston engine was not cumbered with a compressor. Theoretically it should give an indicated economy as good as the Diesel, but it was still young, and did not quite attain to that yet. When it did the brake economy would be better because of the abolition of the compressor. With the approval of the Council he had proposed the appointment of a nomenclature committee on oil engines. He hoped the cycle they had been discussing would be termed the Akroyd cycle. The term Diesel engine might be relegated to engines which drove compressors.

The Author, in reply, said that the question of annealing connecting-rod bolts was one of a highly technical character, and experts differed on the point. The annealing of these bolts was clearly not a matter to be entrusted to an unqualified person. If made of good material they might, after a time, be replaced by spares, and then sent back to the manufacturers to be dealt with. The question of cleaning depended upon so many things, including the class of oil used, that it was not possible to give a definite broad statement. They found, however, that with the improvements made engines required less and less frequent cleaning and attention.

THE HUMAN FACTOR IN INDUSTRY.

The next paper considered was entitled "The Human Factor in Industry," by Mr. A. Ramsay. It was printed in full on page 132 of our last issue. In passing a vote of thanks, after the author had briefly summarised it, the President stated that it was a new departure to have a paper of this type in the Proceedings. He thought at this time it was of the very greatest value.

The first speaker in the discussion was Mr. P. W. Robson, who said he had given much thought to the aspect of affairs dealt with, and had come to the conclusion that much would be gained if we realised the phases through which we had passed which had come to an end in 1914. The phase ending in that year might be termed an experimental period when industry on a large scale was just being applied to the country. The conditions evolved were without any particular order; they just developed, with the broad result that society leant upon them without any guarantee that they, the manufacturers, were really supplying what society actually required. The war period had brought that to an end, and due to a quickening of the aspirations of the masses they now had a demand for intensive organization and effort. However awkward the transition period might be there was no ground for permanent pessimism. It would pass. For the moment they were faced with the effect of power without responsibility. That state must come to an end. He had just returned from the new republican state of Austria, where on the whole the net result appeared to him to be good. The effort there was all in the direction of getting away from the anachronism of power

without responsibility. In the works they had representatives appointed for the staff and workpeople, and questions of discipline were handed to them to be dealt with. Development in this direction might be expected here. The position should be considered with patience and a broad view taken. By patient guidance they would emerge from the present unhappy position and reach something never attained before. Previous ideas must be abandoned—the "Victorian" period if it might so be called. Workmen now had different ideas and they should be glad of the fact. The men were now like boys emerging into manhood—they had the strength of a man but had not reached the mental development sufficient to put that strength to proper uses, and in the meantime did extraordinary things. Wisdom would come with growth. He always had thought that it would take four to five years to reach normality after the war. He was still of that view. There was room for courage and patience. He endorsed the note of warning of the author, but was confident they would find a solution of all these difficulties.

Mr. W. Reavell said it was admirable that the Institution should recognise that these things had to be considered. Some record should go forth of the opinion of the Institution on the question. He had always resented the division of productive industry into the two camps of labour and capital; it was wrong and conveyed wrong impressions to the employee and the public. Though they had to have capitalists they were not so in the same sense as were bankers and speculators. He thought most of them were much more proud of their position and work as engineers than as capitalists. How could they make that evident to their skilled men and employees? It became more and more difficult to see how they could get into close touch with labour and the men they employed. Many of the latter recognised that they had been trained and grown up with them, yet it was increasingly difficult to get into touch and discuss things with them. Engineers as a whole did not see much difficulty in working out the Council schemes. The craftsmen were the first to object to the Whitley Councils. The unskilled workers were generally more willing to see councils adopted than such bodies as the A.S.E. were. It would do good if it went forth from the Institution that the employers recognised that employees were entitled to a greater share of the good things going. The long hours of overtime of the pre-war period could not now be kept up, but by double shifts they would have to get a greater return out of their buildings and machinery owing to their greater cost. It was difficult to get over the workers' suspicions. If the position were adopted that employers were more co-workers with the men, and not so much capitalists, he thought good might come of it.

The author's reply was held over owing to the fact that two papers still remained to be considered. A suggestion was made that the discussion should later be continued in London.

The Uniflow Steam-Engine.

A paper entitled the "Uniflow Steam-Engine" was next taken. It was by Messrs. F. B. Perry, and is reprinted elsewhere in our columns this week.

After a vote of thanks, Mr. H. Pilling opened the discussion. He thought the paper timely, but the subject had been dealt with with undue restraint. The engine described possessed extraordinary advantages. Before the war there were already on the Continent many engines of this type at work. Now the slow speed engine manufacturers over here were combining to undertake research work and propaganda. There had been remarkably little change in slow speed engines for many years past. People were content to put in engines which satisfied their predecessors of thirty or even fifty years ago. The slow engine manufacturers' greatest competition came from the electrical engineers who adopted an altogether different attitude. It was now their intention to combat this competition, and they were relying on the uniflow engine to a large extent as a measure to that end. The paper referred mostly to engines in continuous running. There was a lot of pioneer work to be done in other directions. Some time ago he received the offer of a large sum for the supply of a uniflow engine for a reversing rolling mill. He was not then in a position to close with it, but he thought now he was in a position to do so. If oil-engine makers were asked to supply an engine which would start from rest at any moment under full load, he thought they would find themselves faced with a very nice problem. For Bessemer blowing engines had to be constantly started and stopped with long or short intervals. His firm had been the first to put down a triple expansion engine capable of starting at any time against full accumulator pressure. Had he to-day that same problem he would supply a uniflow engine. The ordinary gear, of course, had to be modified to meet these requirements, and they had devised an hydraulic system in which they pumped the valve open. It was very quiet, looked well, and he thought it would be satisfactory to their customers. The uniflow engine could also be adapted to winding engine work. The engine, however, was one which had to be carefully treated. The parallelism of the cylinder under working conditions, and other points wanted carefully working out. The chief disadvantages arose from having the piston pressure based on full boiler pressure. Generally speaking the design and work should be of superior quality.

Professor G. F. Charnock drew attention to the fact that only a bare mention of the release valve was made in the paper though it was an important detail. He would like to inquire as to the steam-tightness of these valves. He had been told of double beat valves being absolutely tight, yet Sulzers employed a spring seat. Was it possible to make such a valve absolutely tight? The uniflow engine was a single crank engine. How did they get uniformity of turning moment with it? Till recent years a single crank engine was for that reason not generally approved of. In spinning mills uniformity was essential. Could the author give diagrams of speed variation during the revolution? It was encumbent on engineers to make the fullest use of the exhaust which carried away 60 per cent. of the heat. That was lost in condensing. It should, on the other hand, be utilised. It might be possible to add a uniflow low-pressure cylinder to an ordinary engine. It would be tandem and would thus still have disadvantages, but it might be a useful direction to work in.

Mr. P. W. Robson said some years ago they had purchased for a factory abroad in which they were interested a uniflow engine by Sulzer. It was economical, and he could confirm all the claims made in the paper under this heading. They had had one trouble, and that was vibration, and the makers could not get over it. In Russia that firm had done a large business because of the better workmanship and guarantees, though their prices were higher. The uniflow engine required a finer touch.

Mr. W. H. Patchell said he had been responsible for putting in Sulzer engines at Bow and elsewhere, and his example had subsequently been frequently copied. He thought too much was asked of the uniflow engine. It was impossible to get steady turning with one cylinder on one crank. Sulzer's put marvellous work into their engines, which were a credit to any country. They had been bought in competition with British makers. He was pleased to see a reciprocating engine paper before the Institution. None would love a turbine as he would a reciprocating engine. In spite of the Electrical Commissioners it would still have a long life.

Mr. T. Clarkson said he had tried the uniflow engine on motors some twenty-five years ago, but the compression was too great and gave trouble. Had the author any experience with 30 h.p. to 40 h.p. high speed units?

The author in reply said that double beat valves could be made perfectly tight when working at one temperature. The alterations of design were due to the introduction of new conditions, such as superheated steam, &c. Uniformity of turning was a matter of flywheel weight. A two-cylinder engine was only necessary if it was required to start up from any position. Once started the inequalities could be got over by increased weight. The heat of the exhaust should be utilised whenever possible, using a non-condensing engine, and heating by the exhaust. The vibration spoken of by Mr. Robson must, he thought, have been due to insufficient balance at the crank webs. He had not considered the smaller type referred to by Mr. Clarkson, the smallest uniflow engine made by his firm being 50 h.p. running at 220 r.p.m.

Messrs. Marshall's Power Station.

The last paper taken at the meeting was one by Mr. F. J. Cribb, entitled a "Note on the New Power Station for Messrs. Marshall, Sons and Co., Gainsborough." This paper described the station, of which we gave recently a fully illustrated account in our issue of May 21st last, page 673. We also reproduce Mr. Cribb's paper in full in the present issue (*vide* page 164). In it Mr. Cribb gave information with regard to some interesting trials carried out by Captain Sankey on the plant.

The President, in proposing a vote of thanks, said that the test referred to in Mr. Cribb's paper, had been made without any tuning up whatever. When the results were reduced to the design conditions they would be 12 lb. of steam per kilowatt-hour with a thermal efficiency overall of 72·8 per cent. Some years ago he had made a test abroad in which every care had been taken to tune everything up, and he had obtained with a Ljungström turbine an efficiency of 74 per cent. The station at Gainsborough bristled with measuring and recording apparatus, and was exceedingly interesting.

A series of votes of thanks was then passed to all who had already contributed, or who would do so on the following days, to the enjoyment and interest of the members staying in the city. These, it is hardly necessary to say, were passed with enthusiasm.

Visits to Works, &c.

In the afternoon of Wednesday members visited works in Lincoln, as, for instance, Messrs. Ruston and Hornsby's works, Messrs. William Foster and Co.'s works. At the former they were kindly entertained to tea. In the late afternoon a garden party was given by Mr. and Mrs. P. W. Robson at Dunelm House, Lincoln. For the evening a reception had been kindly arranged by the Lincoln engineering firms in the Castle grounds, but unfortunately the weather interfered and it had to be transferred to the County Assembly Rooms. Here a very enjoyable evening was spent, there being no signs whatever of any disorganisation due to the alteration of plans at the last minute.

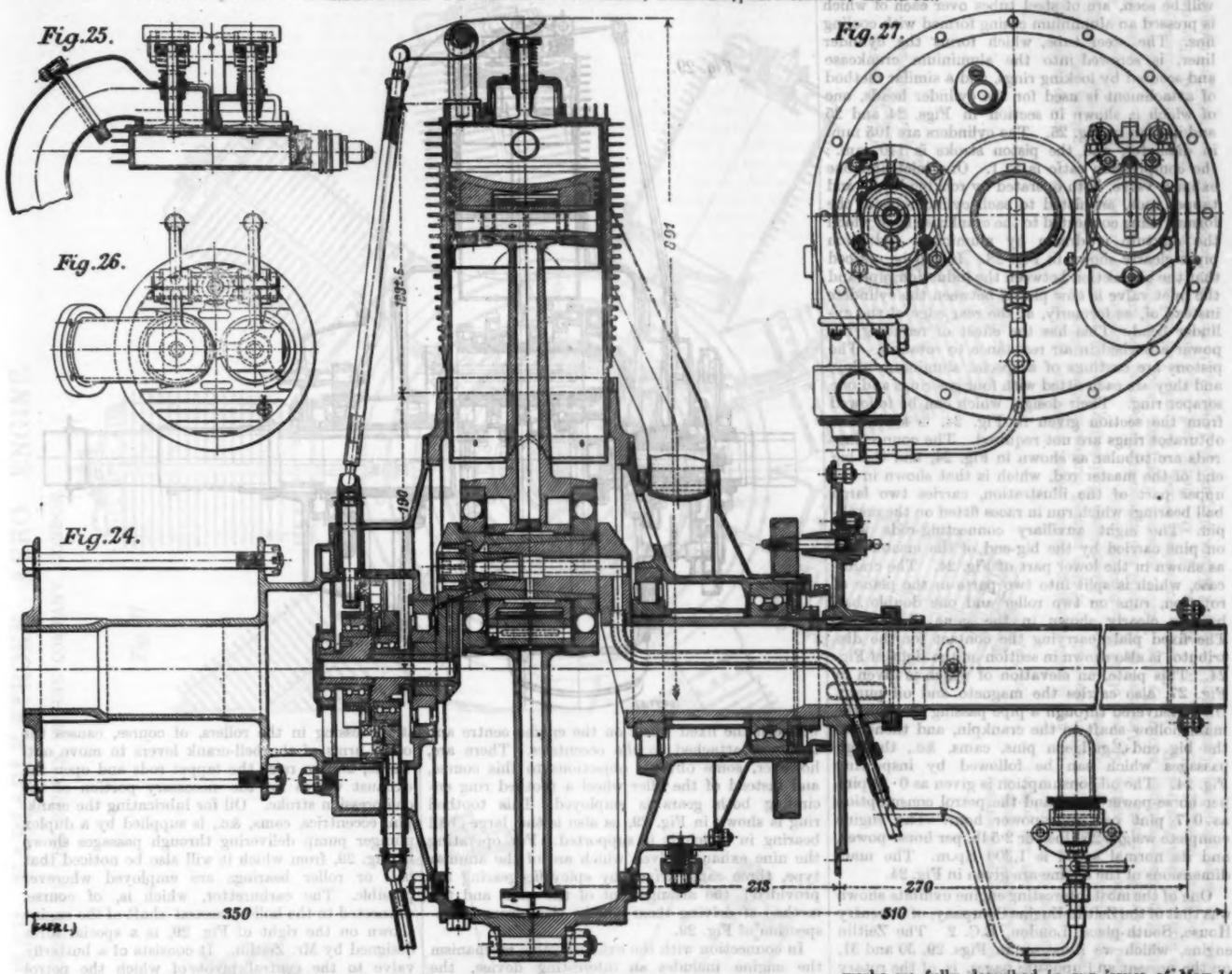
On Thursday, the 22nd, alternative visits were arranged for Frodingham and Scunthorpe, and for Newark. In the former case members went to Scunthorpe and returned by motor chars-a-bancs. At Scunthorpe the Frodingham Ironstone Mines were visited, the party being conducted over the workings by Mr. R. E. Westwood. Here were seen at work several of the excavators and transporters, which had been previously described by Messrs. Livens and Barnes in their paper read on Tuesday. After lunch this party went to Messrs. John Lysaght's Normanby Park Steel works. Here various interesting processes were shown, including coke-oven working and all the modern processes of steel works and rolling mills. An opportunity was also afforded of inspecting two large gas-blowing engines being installed by Messrs. Galloways, Limited. One was already running, but not blowing. It is of 1,250 h.p. and delivers 30,000 cub. ft. of free air per minute. After tea the party returned by motor to Lincoln.

The Newark party visited the firms of Messrs. A. Ransome and Co. and the Underfeed Stoker Company; the adjoining works of Messrs. Ransome and Marles Bearing Company and the works of Messrs. Worthington-Simpson, &c., were also visited. It is impossible to describe these various works at Newark in the present article, but we hope to be able to deal with them at a later date. Visits had also been arranged to the Parish Church and the Castle. A reception was held in the Town Hall by the Mayor, and both luncheon and tea were kindly provided by the engineering firms of Newark.

On Friday, 23rd, visits were paid to Gainsborough to the works of Messrs. Marshall, Sons and Co., Limited, and Messrs. Rose Brothers. The former

100-HORSE-POWER CLERGET AERO ENGINE.

CONSTRUCTED BY MESSRS. GWYNNES, LIMITED, ENGINEERS, LONDON.



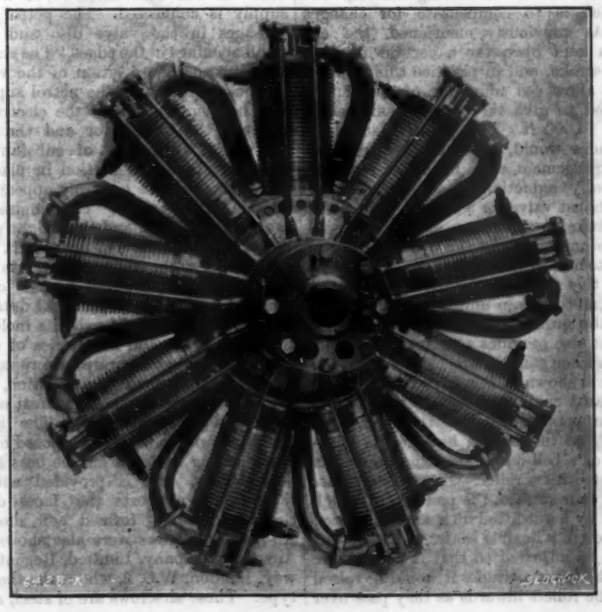


FIG. 28.

works we fully described in our issues of May 14 and 21 last (pages 635 and 670), while at the latter very interesting packetting, wrapping and labelling machines were seen in process of manufacture and at work. The Old Hall at Gainsborough was also visited by permission of Sir H. B. Bacon, Bart. The large party visiting Gainsborough were kindly entertained to lunch and tea by Messrs. Marshall. An alternative visit for Friday arranged for a tour of the Dukeries district in motor chars-a-bancs, with luncheon at Edwinstowe and tea at Southwell, where a visit was paid to the cathedral.

The excursions on Friday concluded the Lincoln meeting, a gathering which on all hands was acknowledged to be a very pleasant and successful revival of pre-war practice, the great interest of the various important works visited and the cordiality with which the members were received leaving nothing to be desired.

THE INTERNATIONAL AERO EXHIBITION.

(*Concluded from page* 109.)

WHEN dealing with Messrs. Gwynnes' exhibit, on page 108, *ante*, we referred to a 100 h.p. nine-cylinder Clerget engine and promised to give a fuller account of it subsequently. We are now able to reproduce a photograph and sectional drawing of this engine in Figs. 24 to 28, on the present page. The engine has been designed since the termination of the war in order to meet the demand for a light

and reliable engine for small and fast commercial aeroplanes. The general character of the design, which includes the chief features of previous Clerget models, is shown in Fig. 24. The cylinders, it will be seen, are of steel tubes over each of which is pressed an aluminium casing formed with cooling fins. The steel tube, which forms the cylinder liner, is screwed into the aluminium crankcase and secured by locking rings, and a similar method of attachment is used for the cylinder heads, one of which is shown in section in Figs. 24 and 25 and in plan in Fig. 26. The cylinders are 105 mm. in diameter, and the piston stroke is 140 mm.; the compression ratio is 5:1. One inlet and one exhaust valve, both operated by rocking levers and tappet rods, are fitted to each cylinder head, the former being connected to the crankcase from which the mixture is drawn by aluminium induction pipes clearly shown in Fig. 28. It will be noticed that the connection between the induction pipe and the inlet valve is now placed between the cylinders instead of, as formerly, at the rear edge of the cylinder head. This has the effect of reducing the power absorbed in air resistance to rotation. The pistons are castings of a special aluminium alloy, and they are each fitted with four gas rings and one scraper ring. Their design, which can be followed from the section given in Fig. 24, is such that obturator rings are not required. The connecting-rods are tubular as shown in Fig. 24, and the big end of the master rod, which is that shown in the upper part of the illustration, carries two large ball bearings which run in races fitted on the crank-pin. The eight auxiliary connecting-rods work on pins carried by the big-end of the master rod, as shown in the lower part of Fig. 24. The crank-case, which is split into two parts in the plane of rotation, runs on two roller and one double ball bearing clearly shown in the same illustration. The fixed plate carrying the contact for the distributor is also shown in section on the right of Fig. 24. This plate, an elevation of which is given in Fig. 27, also carries the magneto and oil pump. Oil is delivered through a pipe passing through the main hollow shaft to the crankpin, and thence to the big ends, gudgeon pins, cams, &c., through passages which can be followed by inspecting Fig. 24. The oil consumption is given as 0·13 pint per horse-power hour, and the petrol consumption as 0·7 pint per horse-power hour. The engine complete weighs 250 lbs., or 2·5 lb. per horse-power, and its normal speed is 1,300 r.p.m. The main dimensions of the engine are given in Fig. 24.

One of the most interesting engine exhibits shown was that of the Zeitlin Engine Company, of Coventry House, South-place, London, E.C. 2. The Zeitlin engine, which we illustrate in Figs. 29, 30 and 31, on the present and opposite pages, is of the rotary air-cooled type with nine cylinders, and its special feature is that the piston stroke is varied for each part of the cycle. This is accomplished by fitting an eccentric to the big end of each connecting-rod, as shown in Fig. 30, and rotating the eccentrics around the crankpin at half the engine speed by means of gearing. The cycle of operations is as follows: on the working stroke the piston travels a distance of 181 mm. returning on the exhaust stroke for a distance of 203·5 mm., so that it clears practically the whole of the exhaust gases out through the exhaust valve which is situated in the cylinder-head, and is operated by a cam tappet rod and rocker arm, as shown in Fig. 29. The exhaust valve remains open for the greater part of the suction stroke, but after it has closed, the piston continues to move for a total distance of 226 mm., uncovering inlet ports in the cylinder liner near the end of the stroke. The inlet ports, which can be seen in both Figs. 29 and 30, are connected with the crank-case and the partial vacuum in the cylinder is sufficient to draw in gas from the crankcase when the ports are uncovered. On the compression stroke, the piston travels a distance of 203·5 mm., compressing the charge into a clearance space of about 22·5 mm. The method of driving the eccentrics on the crankpin is ingenious. In order to reduce the friction as much as possible it is, of course, desirable to rotate the eccentrics in the same direction as the engine, and the most obvious way of doing this would be to fit a small idler pinion between the fixed wheel on the engine centre and the gear attached to the eccentrics. There are, however, some obvious objections to this course, and instead of the idler wheel a toothed ring encircling both gears is employed. This toothed ring is shown in Fig. 29, as also is the large ball bearing in which it is supported. For operating the nine exhaust valves, which are of the annular type, three cams driven by epicyclic gearing are provided; the arrangement of the cams and the method of driving them will be clear from an inspection of Fig. 29.

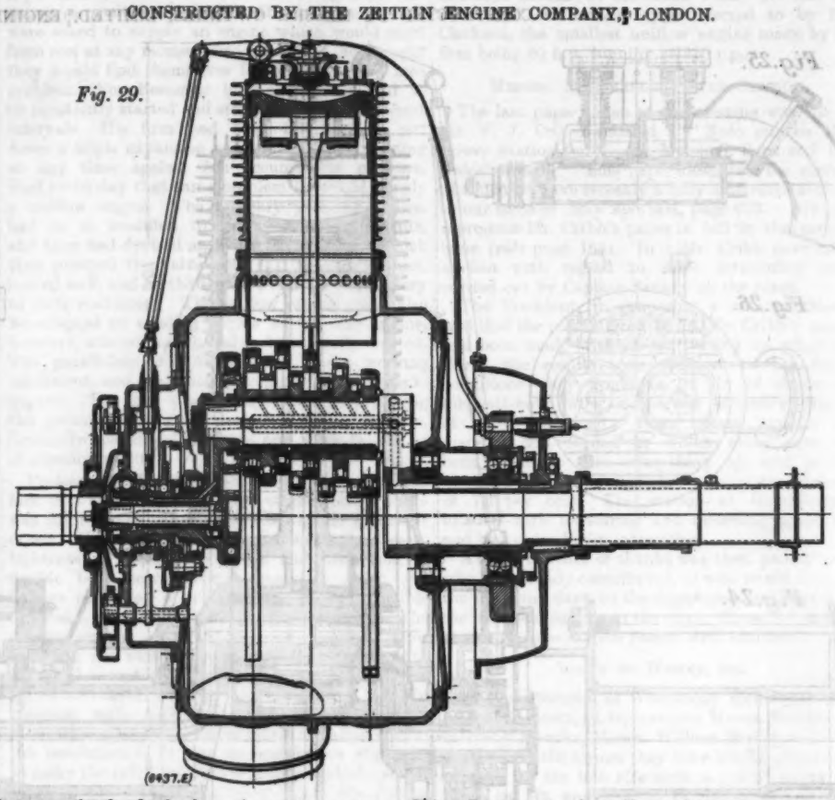
In connection with the exhaust valve mechanism the engine includes an interesting device, the object of which is to compensate for changes in altitude. As previously mentioned, the exhaust valve is kept open for a certain fraction of the suction stroke, and in practice this fraction is arranged to allow the admission of a quantity of air calculated to give the correct compression at a height of 15,000 ft. The quantity admitted at lower altitudes would, therefore, be excessive unless some arrangement were made for reducing it. The necessary reduction is accomplished by opening the exhaust valve for a certain part of the compression stroke so that some of the air is expelled from the outer ends of the cylinders before it has had time to mix with the gas admitted through the ports. In this way it is possible to vary the compression so as to obtain uniform power at any altitude from the ground level to 15,000 ft., and the arrangement also provides a means of reducing the compression when starting up. The mechanism for this purpose is shown in Fig. 31. In this figure one of the exhaust cams is shown dotted, as also are the three tappets operated by this cam. Between the cam and the tappet, however, is interposed one arm of a bell-crank lever the other arm of which is fitted with a roller. These rollers pass over a pivoted cam surface, the position of which can be adjusted by a nut fitted on a screw operated by the pilot through a flexible shaft. At 15,000 ft. the cam would be adjusted so that it cleared the rollers, and at the lower altitudes it would be raised so as to press the rollers inwards as they pass over it. Pressing in the rollers, of course, causes the other arms of the bell-crank levers to move outwards, and so raise the tappet rods and open the exhaust valves for the necessary portion of the compression stroke. Oil for lubricating the crank-pin, eccentrics, cams, &c., is supplied by a duplex plunger pump delivering through passages shown in Fig. 29, from which it will also be noticed that ball or roller bearings are employed wherever possible. The carburettor, which is, of course, connected to the hollow central shaft of the engine shown on the right of Fig. 29, is a special form designed by Mr. Zeitlin. It consists of a butterfly valve to the central pivot of which the petrol supply is connected. The petrol passes through passages in the valve disc and leaves through small openings in the edges. The engine is throttled by adjusting the position of the valve and simultaneously regulating the petrol supply. It should also be mentioned that the electrical connections between the distributor and the sparking plugs are made by means of substantial Duralumin strips of streamline section in place of the usual fine wires, and this certainly appears to be a more reliable arrangement. The engine develops 220 brake horse-power, and the weight per brake horse-power comes out at well below 2 lb.

The only other engine shown was a 300 h.p. Vee-type Hispano-Suiza, but of this engine we were unable to obtain any technical data. There were, however, a number of exhibits including constructional materials and accessories of which, perhaps, the most important were airscrews. Some of the latter were of metal construction, that fitted to the Short all-metal machine dealt with on page 76, *ante*, being of this type. The Short airscrew, which is two-bladed, is composed of a light aluminium casting which forms the boss and the back of both blades, and is provided with an internal ridge which supports the faces of the blades, the faces being formed of sheet aluminium. All-metal airscrews were also shown by the Metal Airscrew Company, Limited, Regent House, Kingsway, London, W.C. 2, who make the Leitner-Watts type. These airscrews are of steel, and the boss is

220-H.P. VARIABLE-STROKE AERO ENGINE.

CONSTRUCTED BY THE ZEITLIN ENGINE COMPANY, LONDON.

Fig. 29.



(6437.E)

220-HORSE-POWER VARIABLE-STROKE AERO ENGINE.

CONSTRUCTED BY THE ZEITLIN ENGINE COMPANY, LONDON.

Fig. 30.

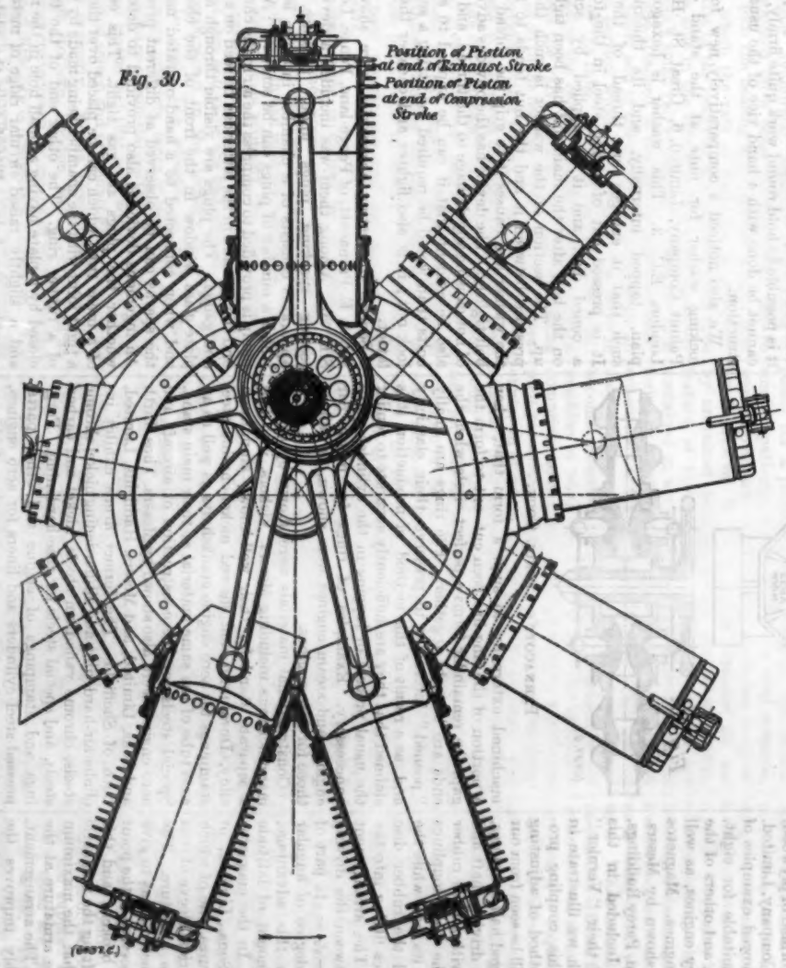
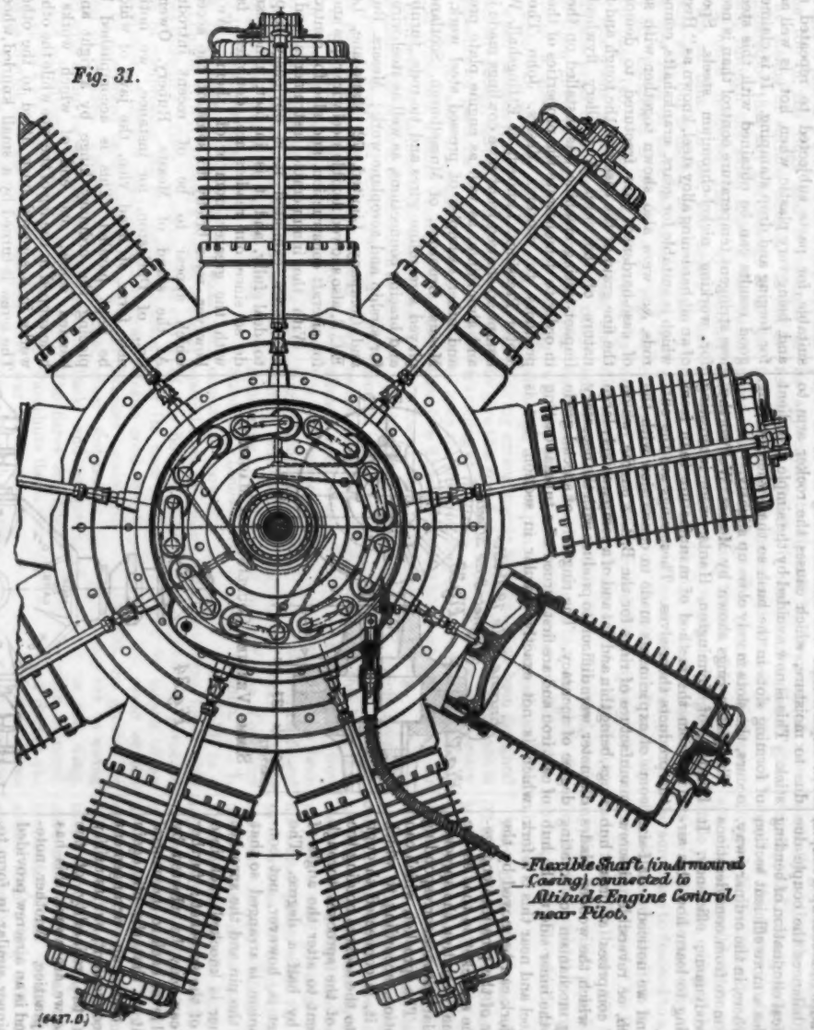


Fig. 31.



composed of two die forgings in the form of cylindrical sleeves with flanges at one end. The unflanged ends are made with dog teeth, and are placed together and afterwards edge-welded into one component. The flanges on the sleeves consist of triangular portions extending on both sides of the centre line, and between the flanges of the pair of sleeves, ribs, or bridge-pieces, are fitted and secured by flush rivets and countersunk screws. The blades, which are composed of mild steel plates formed to the usual aerofoil section, are fixed to the centre portion by edge-welding, and are further supported by the ribs above-mentioned. The ribs are secured by flush rivets and countersunk screws. The plates forming the blades are welded together at the leading and trailing edges, but the joints on the faces are made by means of wire rivets finished flush. These propellers, we understand, have given quite satisfactory results on tests and also in flight, and one tested to destruction at the Royal Aircraft Establishment failed from the fact that the stresses induced exceeded the tensile strength of the steel, tearing off the metal of the blades without affecting the welding. The firm also manufactures propellers with two, three or four detachable and adjustable metal blades. In these propellers the hub is a steel forging and the blades, which are hollow, are built-up of thin pressed, laminated steel sheets, the number of laminations diminishing from the root of the blade towards the tip.

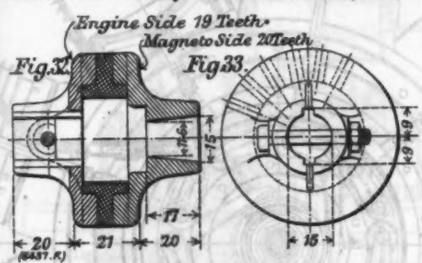
Airscrews of the usual timber construction were shown by the Falcon Airscrew Company, and D. M. Davies, Cottenham-road, Holloway, London, N., Messrs. W. D. Oddy and Co., Limited, of Leeds, and Messrs. Martinsyde, Limited, of Woking. One exhibited by the latter firm was rather of an experimental nature, and represents an interesting attempt to produce a feathering propeller for aircraft. It was of composite steel and timber construction, and the blades which were articulated near their roots, were free to take up such an attitude as to produce practically only pure tensile stresses in the material. The design is such that, in working, the blades set themselves

at a slight angle to the plane of rotation, and the centrifugal force on the blades thus sets up a couple, the magnitude of which balances the couple due to the thrust. The practical elimination of bending stresses in this way enables a more efficient section to be used near the boss where, in the ordinary way, the section is determined more from considerations of strength than of aerodynamic efficiency. It will certainly be interesting to learn how this airscrew behaves in practice.

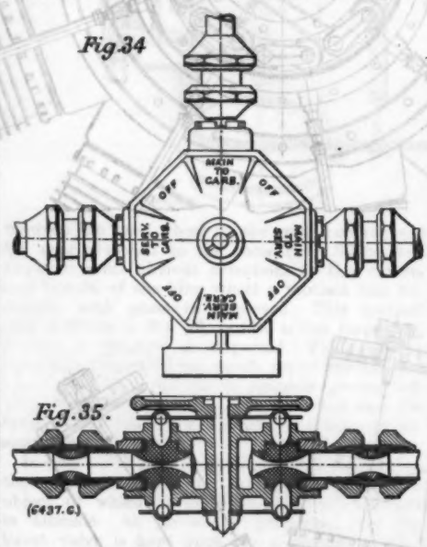
On Messrs. Oddy's stand we noticed a half-size model of a variable pitch, or reversible, airscrew of recent design. This comprises a brass hub provided with sockets in which the wooden blades are fitted and containing mechanism for rotating the blades in flight. On the inner side of the hub is mounted a sprocket wheel and near this is a fork carrying two pins. The fork can be moved by the pilot so as to bring either of the pins into engagement with the teeth of the sprocket so that as the propeller turns through one revolution the sprocket is rotated through an angular distance corresponding to the pitch of the teeth. The sprocket, which can be moved in either direction, according to which of the pins engages with it, is connected through worm gearing in the hub to the sockets holding the blades and the rotation of the sprocket through one tooth space is sufficient to alter the angle of incidence of the blade by half a degree. The movement of the sprocket is, however, not continuous, since the mechanism is arranged so that after each engagement of the pin and the sprocket has taken place the former is knocked back into its normal position clear of the sprocket; further movement of the blade can only be effected by bringing the pilot's control lever back to the neutral position, and re-setting it so that the pin again engages the sprocket. Such an arrangement would, of course, be very convenient, but its utility obviously depends upon the reliability of the mechanism, and, so far as we are aware, this has not yet been tested in practice. Another noteworthy exhibit on this stand is an airscrew provided with a hollow wooden spinner similar in form to, and for the same purpose as, the metal spinners which have been largely employed. The front streamline portion of the spinner is of laminated construction, and the flat back is formed of plywood.

The British Thomson-Houston Company, Limited, Lower Ford-street, Coventry, showed examples of polar-inductor type magnetos suitable for eight, nine and twelve cylinder engines, and others of the rotating armature type for rotary engines, as well as for three, four and six cylinder engines. Magnetos and sparking plugs were also shown by Messrs. Simms Motor Units (1920), Limited, Percy Buildings, Grease-street, London, W. 1. Included in this firm's exhibit were examples of their "Vernier" flexible magneto couplings which we illustrate in Figs. 32 and 33, annexed. This coupling provides a simple and accurate method of adjusting the timing of the spark, and as will be seen from our engravings, it consists of two flanged half couplings, one of which is attached to the driving shaft and the other to the magneto shaft, with a hard rubber disc between them. One of the half couplings is formed with 19 radial teeth on its face, while the other has 20 similar teeth, and the rubber disc is moulded with teeth on its faces fitting into the teeth on the half couplings. The arrangement thus permits an adjustment between the driving shaft and magneto shaft of $\frac{1}{19} - \frac{1}{20} = \frac{1}{380}$ part of a revolution, or less than one degree of angular movement, and in addition to this advantage, the coupling gives a certain amount of latitude in the alignment of the shafts. In the magnetos shown by Messrs. North and Sons, Limited, of Watford, we notice two new features, one of which was the fitting of a slotted cylindrical sleeve of iron in the air gap surrounding the armature. The position of this sleeve can be adjusted so as to give sparks of uniform intensity, irrespective of the point at which the primary circuit is broken, and this is, of course, accomplished by shifting the magnetic flux by means of the sleeve so that the maximum number of lines pass through the armature at the moment when the break occurs. The arrangement, we understand, also considerably improves the sparking at slow speeds. The other feature relates to the design of the fibre bush in which the rocker arm of the contact breaker works. Trouble has been experienced from the swelling of this bush, due to moisture, which causes the rocker arm to stick. This is now avoided by the simple expedient of forming slots in the bush so that, when swelling occurs, the slots merely close up slightly.

The piston rings shown by Messrs. Wellworthy, Limited, of Lymington, Hants, were interesting more from the method of manufacture than from the products themselves. These rings are the outcome of experiments made in connection with the manufacture of rings for the B.R. 2 engine, which rings, being thin and flat and of a comparatively large diameter, were difficult to produce with the necessary degree of accuracy. The rings are of special grade of cast iron and are first turned off a tubular casting which is not exactly circular in section, but is



SIMMS VERNIER COUPLING FOR MAGNETO.



PARNACOTT'S PETROL COCK.

machined externally to such a form that, when a portion of the ring has been cut out to form the gap, the remainder forms a perfect circle when the ends are brought together. The rings are finally "peened" internally to preserve their elasticity and, as a result of this method of production, it is claimed that they are sufficiently accurate to render the usual process of lapping in the cylinder quite unnecessary. Examples of rings for motor car engines and steam engines were shown, as well as those for aero engines.

Constructional materials were shown by several manufacturers including Messrs. Vickers, who had a separate stand for their well-known aluminium alloy, Duralumin, and showed nickel-chrome steel stampings for aero engine crankshafts as well as an axle tube of the same material at their main stand. Special steels for the construction of aircraft and aero engines were also shown by Messrs. Thos. Firth and Sons, Limited, and Messrs. Hadfields, Limited, both of Sheffield. The former firm's exhibit includes air-hardening and oil-hardening nickel chrome steels, chrome vanadium steels, nickel and carbon steels, and special steels for case-hardening. Forgings and stampings of engine and other parts, pressed-steel cylinders and liners for aero engines, stainless steel valves, and many other steel products were also shown. Messrs. Hadfields exhibited test bars illustrating the mechanical properties of their "Era 51" steel, which is particularly suitable for parts subjected to repeated shocks, and, being very plastic when hot, is well adapted for forging and drop stamping. It is claimed that good results can be obtained with this steel with less stringent temperature control than is necessary for working nickel-chromium steels. Specimens of an oil-hardening alloy steel, known as "Hecla 61," which is suitable for gears, crankshafts, connecting-rods, &c., were also shown together with samples of case-hardened bars fractured to demonstrate the fine grain of the case and the tough and fibrous nature of the core. A Guillery flywheel type impact-testing machine was installed on the stand in order to demonstrate the properties of the firm's products to visitors. Messrs. John Thompson Motor Pressings, Limited, of Ettingshall, Wolverhampton, showed front nose cowlings made in steel and aluminium, as well as engine plate pressings, and other examples of pressed steel work, while Messrs. Bruntons, of Musselburgh, Scotland displayed streamline wires and tie-rods, turnbuckles, and bracing connections, as well as steel-wire cables for airship and aeroplane work; Messrs. Bullivant and Company, Limited, 72, Mark-lane, London, E.C. 3, also showed flexible steel wire ropes and cords for aircraft construction, and also for controls.

With the innumerable instruments and small accessories exhibited it is obviously impossible to deal fully, and it is, in fact, unnecessary to do so since our readers are, doubtless, familiar with the greater number of them. We may, however, refer briefly to some of the accessories which appear to be of recent introduction. At the stand of Messrs. Rubery, Owen and Co., of Darlaston, for instance, we noticed a new form of hand vice, the jaws of which can be kept parallel. This is accomplished by replacing the ordinary hinge by a right and left handed screw, one end of which works in a hole tapped in the leg of the vice while the other end works in a screwed bush fitted to the other leg. The screw is turned by a small knurled wheel, and by this means, the lower end of the vice is opened to the same extent as the jaws, which are tightened up on to the work by the usual bolt and fly nut. With this vice, which is known as Wiley's patent, it is possible to hold round work quite firmly, which cannot be done with a hand vice of the usual construction.

We also noticed a comparatively new form of locking washer for nuts at the stand of the Palnut Company, Limited, 6, Great St. Helen's, London, E.C. 3. This washer is hexagonal in plan, tapped internally, and its thickness is such that it engages one thread of the bolt. It is pressed out of spring steel in the form of a coned disc, and it is applied by screwing on the bolt after the main nut has been tightened up. The section of the washer is such that the pressure between it and the nut tends to flatten the washer and causes it to grip the thread of the bolt tightly. The device has the obvious advantage of not causing any damage to the thread, and it will also be evident that it can be applied to shorter bolts than would be required for fitting a separate lock nut; it is also lighter and cheaper than the latter.

Several interesting accessories were shown by Mr. A. E. Parnacott, of Penge-lane, Penge, London, S.E. 20. Among them was included a device for testing sparking plugs under pressure. The apparatus consists of a chamber into the back of which a number of plugs can be screwed. A hand pump is provided to compress the air in the chamber, and the pressure in the latter can be read on a Bourdon gauge. The plugs are visible through a thick plate-glass window in the front of the chamber, and when connected to a hand-operated magneto the sparks can be observed at different pressures. An ingenious device is also provided to determine whether the plugs are gas tight. This consists of a brass tube which can be placed over the plug, a tight joint with the chamber being made by means of a rubber ring. The other end of the tube is closed by a plate having a small hole in the middle and a slightly raised circular ridge of metal surrounding the hole. Fitted over the plate is a glass disc fixed so that it is almost in contact with

the metal ridge, and between the metal plate and the glass disc is placed a drop of oil which spreads along the top of the ridge and is retained in position by means of surface tension. It will be readily understood that any gas leakage from the plug passing through the small hole in the metal plate is at once rendered visible by bubbling through the oil film. In use, the device is not fixed in any way, but is merely held in position by hand. A new form of three-way petrol cock designed by Mr. Parnacott is illustrated in Figs. 34 and 35, on page 140. This cock is operated by means of face cams which depress plungers, and these plungers press on to flexible Venturi tubes and close them more or less. The flexible tubes are made of a special oil and petrol resisting material, which can, however, be easily and cheaply renewed when necessary, and the arrangement has the obvious advantage, that the action is not affected by the presence of particles of grit or other solid matter. Fig. 33 also illustrates a flexible pipe joint which consists of a short Venturi tube section made of gunmetal, or stainless steel, and is fitted between the ends of the pipes to be connected as shown. Over the joint a section of petrol resisting rubber tubing is passed, the ends of this tubing being clamped to the pipes by aluminium, or gun-metal, nuts with tapered threads. This joint has been tested by the Air Ministry and found quite tight with petrol at a pressure of 20 lb. per square inch, and a longitudinal pull of 34 lb. was found to be necessary to break the joint.

Messrs. L. Ripault, & Co., 1, King's Road, St. Pancras, London, N.W.1, showed a number of useful accessories including "Oleo" sparking plugs and a new form of compression tap for engine cylinders. In this compression tap the usual plug and lever are replaced by a screwed valve operated by a small handwheel of ebonite. The top of the handwheel is formed with a cup for priming the cylinder with petrol. The advantages of the screw down valve over the plug cock are, of course, that it is impossible for the parts to stick and that there is less likelihood of leakage. Another interesting item at Messrs. Ripault's stand was a new line of sight-feed lubricators provided with simple and effective means for regulating the feed. These lubricators comprise an unbreakable cylindrical reservoir constructed of mica, mounted on a brass casting which can be screwed into the bearing and contains a sight hole through which the rate of feed can be observed. In the axis of the reservoir is a vertical brass tube having a hole in the side near the lower end over which hole a small valve is clipped. Inside the tube is a spindle attached to the cap of the lubricator, and the lower end of the spindle is formed with an eccentric portion which engages with the valve in the side of the tube. Turning the cap of the lubricator rotates the central spindle, and the eccentric part opens the valve more or less, thus regulating the flow of oil to the bearing. The top of the lubricator is provided with a simple device for locking the cap in any position and also has a numbered scale so that the cap can easily be re-set in the position found to give the correct rate of feed, after it has been moved for any reason. The reservoir can be filled without removing the cap, and there are no other loose parts liable to be lost. The lubricators are of neat appearance and are comparatively inexpensive.

Now that flying is carried on in almost any weather it becomes necessary to devise means for reducing, as far as possible, the difficulties and dangers of flying in bad weather conditions. At the present time, fog is probably the most dangerous meteorological state the airman has to contend with, but rain and snow are bad enough, especially when encountered in the locality in which it is desired to land. The presence of rain on snow must always interfere, more or less, with visibility, but in ordinary circumstances the effect is materially increased by the fact that both adhere to the transparent wind screen and prevent the pilot from seeing through it clearly. Messrs. George Kent, Limited, 199, High Holborn, London, W.C. 1, exhibited an interesting contrivance by means of which the last mentioned difficulty is completely eliminated. The device, which is known as the clear-view screen, has already been employed to a considerable extent at sea, and its marine application was described on page 453 of our one hundred and eighth volume; its application to aircraft is, however, of more recent date. Briefly, it consists of a disc of glass fitted in the wind screen and rotated in its own plane at a fairly high speed so that the rain or snow falling on it is immediately thrown off by centrifugal action. On an aeroplane power for driving the glass disc is obtained either from a small airscrew, or windmill, fitted on one of the struts, or in any other convenient position, or by means of suitably designed vanes fitted round the periphery of the disc itself; the latter arrangement has the obvious advantage that the whole device is entirely self-contained. It has been found that the glass disc will keep quite clear at any speed above 800 r.p.m., although 1,200 r.p.m. is the best speed, and the driving arrangements have therefore been designed to give this speed of rotation when the aeroplane is travelling at 75 m.p.h. It is, of course, unnecessary to keep the disc rotating in clear weather, and it is therefore fitted with a brake which has merely to be released when rain or snow is falling.

Night flying is another matter, which must be studied in connection with civil aviation, although considerable experience in work of this kind has already been obtained in the course of the war. For this purpose the Holt landing light has been largely employed, and it will doubtless be found equally suitable for commercial work. These appliances, which were shown by the Yorkshire Steel Co., Limited, 30, Holborn, London, E.C. 1, consist of powerful pyrotechnic flares held in a special form of bracket attached to the lower side of the bottom plane. The bracket is pivotted near its base and kept vertical by means of an elastic cord, which stretches in the event of the bracket coming into contact with the ground or other obstruction, allowing the bracket to swing back, and so preventing damage to the wing. The flares are ignited electrically when required. Parachute flares were also largely used during the war for illuminating large areas of ground in connection with bombing or other operations and examples of these were also shown by the Yorkshire Steel Company. One example exhibited was capable of giving a light of one million candle power for a period of seven minutes, but several smaller patterns, more suitable for civil aviation, were also shown. Life-saving parachutes, designed by Lieut.-Col. H. S. Holt and intended for use by untrained passengers, were another interesting feature of this exhibit. These parachutes are contained in a specially designed receptacle which forms an integral part of the passenger's jacket, and are entirely automatic in action, the wearer having only to jump overboard if such a course should become necessary owing to some accident to the machine to which he is travelling. The apparatus comprises an auxiliary pilot parachute, a principal pilot parachute and the main weight carrying parachute, all of which are arranged in tandem. The auxiliary pilot parachute is not essential, its object being to get the principal pilot parachute into position for inflation as quickly as possible; the latter will open of itself, though the operation will take place more slowly if the former should fail to function. The two pilot parachutes are released by a mechanical delay device set in motion by withdrawing a plug before the wearer jumps from the aeroplane, but if for any reason the delay mechanism should fail to act, the parachutes can still be released by withdrawing another short-circuiting plug which cuts out the delay mechanism altogether. When the principal pilot parachute opens, it withdraws the main parachute from its receptacle, but owing to the fact that the whole apparatus is then falling comparatively slowly, there is no tendency for the main parachute to open until the lines are fully extended, and consequently the load is taken up with but little shock.

For dropping mails and similar matter from an aeroplane in flight an interesting device known as the "Air Postman," also designed by Lieut.-Colonel Holt, was exhibited. With this device the mails, when launched from an aeroplane, are at first retarded by a small parachute only, so that they fall at the comparatively high velocity of from 70 ft. to 130 ft. per minute, but when they have fallen to within a certain pre-determined distance from the ground, a large parachute is opened automatically, so that the mails reach the earth at a low velocity, and, consequently, without damage. The object of the invention is to enable mails to be dropped from a considerable height into a small space, which would not be possible with an ordinary single parachute, owing to the drift due to the wind. Its use avoids the necessity, which usually exists, for the aeroplane to descend to a low altitude in order to deposit the mails within a reasonably small area. The standard size of "Air Postman" is designed to carry from 20 lb. to 250 lb. of mails, and it is supplied with pilot parachutes of three different sizes to deal with this range of loads; the parachutes, it may be added, can be changed in a few minutes.

Two firms—the Gas Accumulator Company (U.K.), Limited, of Brentford and Middlesex; Messrs. Chance Bros. and Co., Limited, of Smethwick, Birmingham—exhibited lighthouses specially designed for assisting aerial navigation at night. On the stand of the first-mentioned firm we noticed a powerful flashing light using dissolved acetylene in conjunction with incandescent mantles, and intended for use on permanent flying routes. The optical elements are divided into two groups, one of which projects a very powerful beam slightly above the horizontal plane, while the other can be arranged to distribute the light at greater angles with the horizon. At any altitude up to 8,000 ft. an aeroplane remains in the main beam until it is within about 8 miles of the light, at which distance the light itself is easily visible. Another rather less powerful flashing light shown by this firm is of the portable type, and can be fitted with telegraphic apparatus for special signalling. This light also employs dissolved acetylene, but uses open-type burners, and the optical system consists of a split dioptric drum so arranged that the light beam has a maximum intensity at about 5 deg. above the horizontal plane. In all directions making greater angles than 5 deg. with the horizontal, the light source is visible directly. In a somewhat similar, but still smaller, flashing light exhibited, part of the light from the dioptric drum lens fitted is intercepted by reflectors and projected over the whole of the upper hemisphere. In all these lights the flashing mechanism can be adjusted to give a flash of any designed character, and they can be designed so as to require no attention whatever for a period up to a year. They may be lighted and extinguished by solar radiation, which causes differential expansion between a blackened brass cylinder and three gilded brass tubes surrounding the cylinder, the arrangement being entirely independent of the air temperature. When incandescent mantles are used simple mechanism is fitted for automatically replacing them when broken, as many as twelve mantles being held in reserve, if required. Messrs. Chance Brothers' exhibit included a revolving light similar to those used in marine navigation, but provided with special lenses to direct the light upwards, and another light with a fixed-type lens, fitted with automatic flashing mechanism, giving a light for one second, followed by a dark period of four seconds' duration. In both cases dissolved acetylene is used as the illuminant. The firm also showed a 20 in. oxy-acetylene searchlight, suitable for use as a landing light, and for other similar purposes. In this case the light is produced by a pastille of special material heated by an oxy-acetylene blowpipe, supplied with gas from steel cylinders. The whole apparatus is self-contained and easily portable.

Although the demands upon our space have made it necessary to omit all reference to many of the exhibits, including some by no means uninteresting or unimportant, we think it will be admitted that the account we have given of the exhibition is sufficient to justify the remarks made at the outset, on page 74 *ante*, to the effect that our manufacturers are endeavouring to secure for British civil aviation the leading position held by British military aviation at the time of the Armistice. Their efforts, however, need the support of both statesmen and public, and if these are forthcoming we have little doubt of the result. Before concluding, however, brief reference should be made to the exhibit of the Aircraft Disposal Company, Limited, of Regent House,

Kingsway, London, W.C. 2, who occupied the whole of the annexe with an historical collection of machines, engines and accessories used during the war, and purchased by the company from the Government, as mentioned on page 588 of our last volume. The Air Ministry's exhibit in the gallery should also be mentioned. This was divided into sections dealing with aircraft armament, inspection and testing of materials and components, aerial photography, navigation, wireless telegraphy and telephony, airships, and the medical features of aviation. To treat these matters fully would obviously occupy as much space as we have already devoted to the exhibition. Those who studied it, however, could hardly fail to be impressed with the magnitude of British efforts to secure aerial supremacy in the war, and many must have been surprised at the number of branches of applied science which were called upon to assist in the attainment of that supremacy.

H.M. AIRSHIP "R. 80."

We have already given, on page 797 of our one hundred and seventh volume, some general particulars of H.M. rigid airship R. 80, together with some illustrations showing the early stages of the construction of the ship. The vessel has recently carried out a successful trial flight from Barrow where she was constructed by Messrs. Vickers, Limited, and we now propose to give a more detailed account of the vessel, drawings of which are reproduced on Plate XVIII, which accompanies this issue. We also reproduce a number of photographs of the airship on Plates XVII and XIX and also on pages 143, 144 and 150.

In order to render the present article intelligible, it will be necessary to repeat some of the general particulars of the vessel already given in the previous article above referred to. A general view of the completed vessel is given in Fig. 17 on page 143, but a rather better idea of its proportions will be obtained from an examination of Fig. 1 on Plate XVIII. The overall length of the hull, which is of good streamline form, is 529 ft., without the mooring attachment shown on the latter illustration. This device increases the length of the ship by 5 ft., making the total length 534 ft. The gas capacity is rather more than 1,250,000 cub. ft., giving a gross displacement of 38·25 tons. Of this 17·8 tons (46·3 per cent.), is disposable lift. In section the hull for the greater part of its length is a uniform polygon having 21 sides, and the diameter of the circumscribing circle at the largest part is 70 ft. 7½ in. which also represents the maximum width. The overall height of the ship from the bottom of the bumping bags on the cars to the top of the hull is 86 ft. 5 in. when the axis is horizontal. The ship is propelled at a maximum speed of 65 m.p.h. by four engines carried in three cars suspended from the hull structure and developing 1,000 h.p. at full power. The speed at normal power is 60 m.p.h., and at cruising power 50 m.p.h., at which speed the range would be 6,400 miles. The range at full power would be 3,900 miles, and at normal power 4,500 miles. The minimum weight of crew, stores and ballast required for a prolonged flight is 3·8 tons leaving the remainder of the disposable lift (14 tons) available for fuel and oil. The maximum height attainable by the ship as a free balloon is 19,500 ft., but, with full crew and stores, the maximum height that could be reached would be 17,000 ft.

The streamline form of the hull is of the most efficient shape possible for the length and diameter of the ship (these dimensions being limited by the size of the shed), as determined by tests of scale models. Fig. 4 on Plate XVIII shows clearly the general arrangement of the framing. Main transverse frames occur between the gasbag ends, and intermediate transverse frames are placed midway between them. There are 11 main longitudinals, and 10 intermediate ones, all hull framework girders being of triangular cross-section. Transverse wiring, which is fitted at the main frames only, is shown in Fig. 9, and is arranged to transmit the lift of the gas to the keel girder, and to maintain the shape of the transverse section, whilst a longitudinal stay connects the transverse wiring at each main frame, to assist in distributing the gasbag end pressures. The main diagonal bracing wires consist of three series—major, minor and mesh wiring. The first two are on the external surface of the ship, the major wiring forming diagonals in the panels formed by the main longitudinal and main transverse girders, whilst the minor wiring joins the corners of the panels formed by the main longitudinal and main and intermediate transverse girders. The mesh wiring, which is on the inner surface of the girders, and is indicated in the centre part of Fig. 4, transmits the gasbag lifting pressures to the framework. The pitch of the mesh is half a metre square. The keel girder is of triangular form in cross-section, having its base formed by the lowest flat of the transverse frame polygon. This keel contains the cabins, bombs, petrol, water ballast, &c., and is sufficiently strong to transmit all loading, including the weight of the cars, to the main structure. The members of the keel structure are mostly triangular, consisting of three channel sections braced together by bracing pieces made from stampings. In certain cases the girders are square in section, consisting of four sections similarly braced. A walking way is provided throughout the entire length of the keel girder, with branches to the wing cars.

Fig. 18 on Plate XVII is a general view of the completed hull framework before the gasbags have been put in place. The gas vent trunks, which will be referred to later, and the corridor framework are also clearly shown in this illustration. A more detailed view of the latter is given in Fig. 21 on Plate XIX, which also shows the flooring of the officers' quarters and the section utilised for petrol storage.

The total gas space is divided into 15 compartments, as shown in Fig. 3 on Plate XVIII each compartment containing one gasbag. The maximum length of any one of these bags is 10 metres, and they are fitted with inspection windows, purity connections, filling necks, automatic gas valves, and manœuvring gas valves where necessary. The construction of these valves will be clear from an inspection of the half-tone engravings, Figs. 24 and 25, on page 144, which illustrate the automatic and manœuvring valves respectively. Fig. 20 on Plate XIX shows the operation of inflating the gasbags in progress, the bags being about half full, and also shows the fitting of the outer cover, which is made in a number of separate panels laced to the girders; the joint space is afterwards covered with a sealing strip. A walking way and hand-line runs along the top of the hull, and there is also a gun platform forward, access to which is obtained by means of a climbing tube running up between two of the gasbags. This gun platform can be distinguished in the general view, Fig. 17, on page 143. Ventilation shafts, shown in Fig. 18 on Plate XVII, are placed between the gasbags—one to each pair of bags, to allow any gas discharged by the automatic valves to escape, and also to ventilate the corridor.

The arrangement of the vertical fin and rudders is shown on the left of Fig. 1, while Fig. 2 is a similar illustration of the horizontal fin and elevators. The framing of these parts is shown, respectively, in Figs. 4 and 5. The fin girders are of similar construction to the hull girders. The top and horizontal fins each have an area of 715 sq. ft., whilst the bottom fin has an area of 380 sq. ft. The top rudder and elevators each have an area of 250 sq. ft., and the bottom rudder an area of 150 sq. ft. The unbalanced load due to the overhang of the elevators is taken up by a spring working through a fusee, which equalises the load throughout the travel.

There are actually four cars suspended from the hull, although as the two forward cars are placed one immediately behind the other and are joined together flexibly to form one streamline shape, the statement made at the outset that the ship is provided with three cars is practically correct. The forward cars are suspended centrally under the keel of the ship towards the nose, their longitudinal position being shown in Figs. 1, 3 and 4 on Plate XVIII. Figs. 11 to 16 on the same Plate show the construction and arrangement of the cars in detail. The forward car of these two is used for navigating the ship, and contains all navigating controls and instruments, as well as a separate compartment for the wireless apparatus and operator. The after car accommodates two engines driving a single pusher airscrew. Fig 22 on page 144 is an interior view of the control and navigating compartment, looking forward, and showing the engine telegraphs, inter-communication telephones, mooring controls and water-ballast controls, and an exterior view of the framework of both cars is given in Fig. 26, on page 150. The ship is also fitted with two wing cars placed amidships on either side of the centre line, as will be clear from the end elevations and cross sections of the ship, Figs. 6 to 10 on Plate XVIII. Both cars are suspended from the same frame, and each car contains one set of engines. An internal view of one of the wing cars, looking aft, and showing the aluminium framework in which the radiator slides, is given in Fig. 19 on Plate XVII. In the background of this view the tubular construction of the engine bearers is also visible. Fig. 23, on page 144, is an interior view of the completed car looking aft and showing the control positions and radiator slides. One of the radiators is partly visible in this view, as also are the flexible tubes conducting water to and from the radiator. An external view of the framework of this car is also given in Fig. 27 on page 150, in which view the engine can be distinguished inside.

All the cars have been specially designed to give, as nearly as practicable, a perfect streamline shape. They are constructed of Duralumin sections, and in the case of the machinery cars, are plated on the lower portions and covered, in way of the engines, with asbestos fabric. The control car is entirely covered with ordinary fabric. Opening windows of "Triplex" glass are fitted where required, and opening and fixed windows of non-inflammable celluloid are provided in positions of less importance. Portable sections are arranged in the sides of the machinery cars to facilitate removal of the engines. Handling rails are provided, and access to the keel is obtained by means of ladders encased in streamline tubes. All the cars are fitted with special inflated buffer bags, shown in Fig. 11 on Plate XVIII, which have sufficient buoyancy to enable the ship to alight and float safely on the water; they also make an effective cushion when landing on the ground.

All the controls from the forward navigating car are conducted aft under the deck of the car, and up through the access trunk to the keel, whence they are taken either forward or aft. Along the keel all controls are operated by means of wires which run through fairleads placed at frequent intervals; pulleys are only employed where a change of direction is necessary. All wires, pulleys, and shafts between the cars and the keel are faired in by the access trunk. The rudders and elevators are required to work through a total angle of 40 deg., and to obtain this angle 12 turns are necessary on the steering wheel in the car. The travel of the connected end of the kingpost on the rudder or elevator is 3 ft. From the handwheel position to the keel, the gear consists of torsion shafts and mitre gearboxes. These shafts run down from the handwheel aft under the car deck, and thence up to the keel through the access trunk. Under the deck the shafts are provided with flexible joints to ensure free running under load conditions. Universal and sliding joints are fitted on the vertical shafts to the keel, their function being to prevent the controls from being rendered inoperative by a faulty landing. The vertical shafts operate a bevel gearbox with a 3 : 1 reduction situated in the keel. The slow speed shaft from this gearbox runs athwartships, and drives a chain sprocket, the chain of which is connected to the main operating wire which runs along the keel to the kingposts. At the aft end of the ship the use of large diameter pulleys is necessary to conduct the wire to the various kingposts, and these pulleys are mounted on suitable points of the hull structure. Large luminous indicators are provided in the control car to indicate degrees of helm and of elevation.

The gas valve controls are operated by wires which run with the other controls until they are conducted up between the gasbags, the latter being protected by fairing tubes in which the wires are encased. Provision is made in the control car for

H.M. RIGID AIRSHIP "R. 80."

CONSTRUCTED BY MESSRS. VICKERS LIMITED, BARROW-IN-FURNESS.

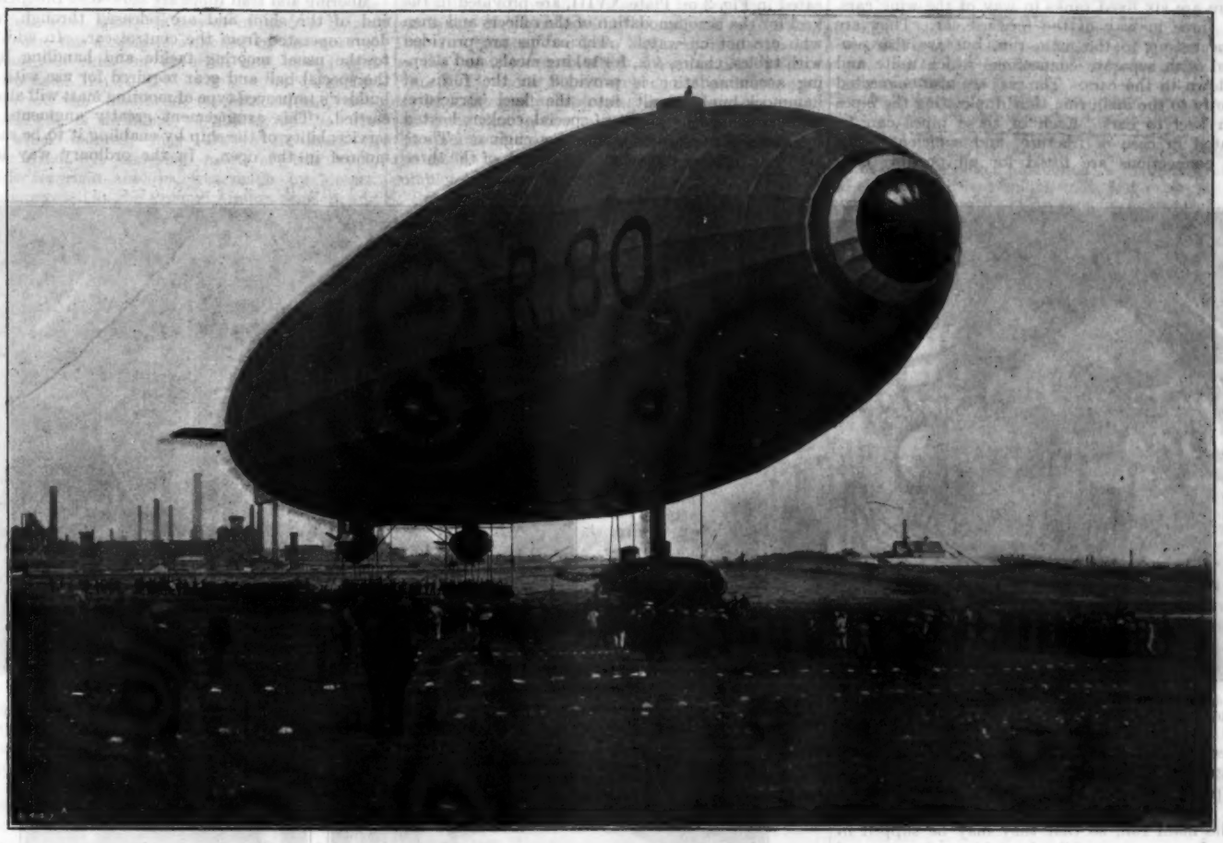


FIG. 17. AIRSHIP PREPARING FOR TRIAL FLIGHT.

operating all the gas valves (six in number) either simultaneously, singly, or in any desired combination. This is effected by a series of small cone clutches which can readily be thrown in or out of gear. Telegraph communication is provided from the control car to all the other cars. The instruments are of the non-reply type, and have large luminous dials. One turn of the handle gives an order and rings the bell of both the transmitting and receiving instruments. Speaking tubes are also arranged between the control car and the officers' quarters in the keel, attention being attracted by means of gongs at both ends of each tube.

The power plant consists of four Wolseley-Maybach engines, each developing a maximum of 230 brake horse-power at 1,400 r.p.m. These engines, it may be added, have proved eminently suitable for airship work on account of their reliability and low fuel consumption. As previously mentioned there are two engines arranged *en échelon* in the forward car and driving a single propeller through spur reduction gear, without a reverse. The drive from each engine is taken through a plate clutch, and through shafting to the reduction gear box at the aft end of the car, where a spur pinion on each pinion shaft drives a spur wheel on a short propeller shaft. An examination of Figs. 11 and 12 on Plate XVIII will make the arrangement clear. A hand brake and drum are fitted on the propeller shaft to lock the propeller in a horizontal position when landing, and each engine may be uncoupled from its pinion drive by means of sliding dog clutches. In the wing cars the drive from the engines is taken through a plate clutch to a gear box at the aft end of the car, on which the propeller is mounted. A hand brake is provided at the aft end of the gear box to control the propeller. Reversing gear is fitted in the gear boxes of the wing cars, comprising a lay-shaft with a sliding spur wheel. A dog clutch is fitted so that, when running ahead, the propeller is driven directly at engine speed. All engine controls are arranged to be operated by one man at the control position in each car, as shown in Fig. 23 on page 144.

Each engine is cooled by a separate radiator, the outside (or block) dimensions of which are about 37¾ in. square by 5½ in. thick. The water capacity of each radiator is 11 galls., and no separate reserve tank is used. To allow for varying conditions of running, and to ensure that the air resistance of the radiators shall be a minimum consistent with the cooling required, each radiator is mounted in a vertical slide, above referred to, in which it can be raised or lowered by means of a small worm gear winch, so that only the required amount of surface projects outside the car. The water pipes connected to the radiators, and shown in Fig. 23 on page 144, are of flexible armoured hose. A thermometer is fitted to indicate the temperature on the hot water side.

The exhaust silencers which are shown in the plan Fig. 12 on Plate XVIII are of the air cooled type, consisting of an inner pipe, through which the exhaust gases flow, and an outer casing, separated by longitudinal fins. Air is drawn through the annular space, in which the fins are situated, by the injector action of the exhaust gases, and by the forward motion of the ship. The exhaust manifold on the engine, and a portion of the pipe leading therefrom, are water-jacketed, to obviate risk of fire.

The clutches are of the grooved multiple-disc type driven from the flywheel by a form of universal joint, consisting of a number of brass-faced leather blocks, and supported at the aft end by a ball bearing mounted in a casing secured to the structure. Pressure is applied to the discs by a central spring, which may be compressed by means of a lever actuating eccentrics, thus allowing the clutch to slip when required. A clutch stop is fitted to facilitate engagement of the gearbox dog clutches. The gearbox in the forward car, which takes the power of two engines, is of the ordinary spur gear type, with a reduction ratio of 17 : 45. The thrust block in this case is a separate unit, consisting of a double ball thrust bearing and a roller bearing mounted in a housing carried at the aft end of the structure. The forward end of the propeller shaft is steadied by the gear-box. The diameter of the two-bladed propeller on the forward car is 20 ft., and it runs at 530 r.p.m., whilst the wing car propellers, which are also two-bladed, are each 10 ft. 6 in. diameter, and run at the same speed as the engines, 1,400 r.p.m.; on the reverse, they run at two-thirds the engine speed.

The petrol is stored mainly in the keel corridor in vertical tanks, some of which are shown in Fig. 21, on Plate XIX, and were referred to previously. Their general arrangement is indicated in Fig. 3 on Plate XVIII, which should be examined in connection with the following description. These tanks, each of which has a capacity of 92 gallons when 95 per cent. full, are slung from the box girder, and steadied by king-posted girders. There are 34 tanks in all, giving a total capacity of 3,128 gallons, which, at a specific gravity of 0.725, weighs 22,650 lbs., or about 10 tons. Seventeen tanks may be readily slipped overboard to act as ballast. These slip-tanks have no bottom connections, and petrol is drawn from them by means of a semi-rotary pump with a suction pipe inside the tanks. The pump discharges into the main run, as the petrol pipe which runs from end to end of the system, is called, the foot valves of certain other tanks being opened at the same time so that

the petrol can ascend into them. The fixed tanks, which act as service tanks and are kept filled from the other tanks, are situated in the corridor in the vicinity of the cars, and are placed fore and aft of the cars so as to allow for all angles of pitch. There are six fixed tanks in way of the wing cars, and three in way of the forward car. They are connected-up to the main run, but are also provided with separate connections which unite and go down to the cars. The cars are also connected directly to the main run, thus duplicating the pipes from keel to cars. Each of these pipes can be isolated in case of fracture, and sufficient cocks and connections are fitted for all possible contingencies of fracture and angle of pitch. Between the groups of slip tanks and fixed tanks is another group of eight special tanks. These are provided with readily detachable connections leading down to the main run, so that they may be slipped in case of emergency, whilst by taking advantage of the angles of inclination of the ship, the fixed tanks may be filled from them without using the hand pump. These tanks are not connected directly to the cars owing to the fact that they are at a considerable distance from the cars in a longitudinal direction. Excessive pressures might, therefore, occur in certain circumstances, and for the same reason it is considered inadvisable to feed the cars directly from the main run. All tanks are fitted with a screwed-on cap having a short filter tube, for filling by means of a hose, and also used, in the case of the slip tanks, for inserting the pump suction pipe. The fixed tanks only are provided with depth gauges of the float, cord and dial type, made by Messrs. Dewrance. Oil is carried in rectangular reserve tanks in the cars—one tank for each engine. These tanks are heated by a branch from the engine water-cooling system, and the capacity of each tank, when 95 per cent full, is 53 gallons. The weight of oil per tank at specific gravity of 0·962, which is the figure for castor oil, is 510 lbs. The total weight of oil carried in the reserve tanks is 2,040 lbs., and, in addition, there is a small amount carried in the various service tanks.

Water ballast is controlled by means of a wire which runs from the navigating car to each water-bag, and operates a valve. The water ballast is divided into two sections, arranged as shown in Fig. 3 on Plate XVIII, one being for emergency use, and consisting of four bags forward and four bags aft, while the other is used for ordinary manœuvring. The whole contents of an emergency bag are discharged when the valve is operated once, whereas any desired amount may be allowed to flow out of the manœuvring ballast bags at will. The total weight of the emergency water ballast is 4,000 lb., the total being equally divided between the fore and aft bags, while the four manœuvring bags are capable of holding 2,200 lb. In order to discharge the emergency ballast it is necessary for the operator to break a paper diaphragm in order to reach the lever. This affords a safe indication as to which bags are available for use at a moment's notice.

Separate quarters, the position of which is indicated in Fig. 3 on Plate XVIII, are provided in the keel for the accommodation of the officers and men who are not on watch. The cabins are provided with tables, chairs, &c., for taking meals, and sleeping accommodation is provided in the form of hammock-bunks built into the keel structure. Food is cooked by means of special cookers heated by the exhaust gases from the engines. There are three lighting dynamos, one in each of the three cars, which are driven by roller chains from forward extensions of the crankshafts. Each dynamo has an output of about 12 amperes at 12 volts. Two wireless generators are also provided, one of which is permanently fixed in the forward machinery car, while the other may be fitted up in either of the wing cars as may be required; means for mounting and driving these generators is provided in each of the cars.

The armament for which the R. 80 has been designed includes eight 230-lb. bombs, which are stowed horizontally in the keel and can be released electrically from the control car. She also carries an automatic quick-firing two-pounder gun, and two Lewis guns on the top forward gun platform. Another gun position in the tail is also provided with two Lewis guns, and similar weapons are fitted in the cars—one on each side of the forward car, and one in each of the wing cars.

Mooring and trail ropes are stowed at the forward end of the ship, and are released through trap-doors operated from the control car. In addition to the usual mooring tackle and handling lines, the special ball and gear required for use with the builder's improved type of mooring mast will also be carried. This arrangement greatly augments the serviceability of the ship by enabling it to be safely moored in the open. In the ordinary way it is the difficulty of getting a large airship into and out of its shed in rough weather that restricts its usefulness, and not the effect of the weather on the ship in the air. The man-power required to handle a rigid airship on the ground by the usual method is also out of all proportion to the object attained, as even under the calmest conditions, a body of upwards of 300 men—according to the size of airship—must be kept standing by whenever a flight or landing is expected to take place. The problem of landing and mooring a rigid airship by mechanical means is one which has, therefore, engaged the attention of aircraft designers for some years past, although but little success attended the earlier

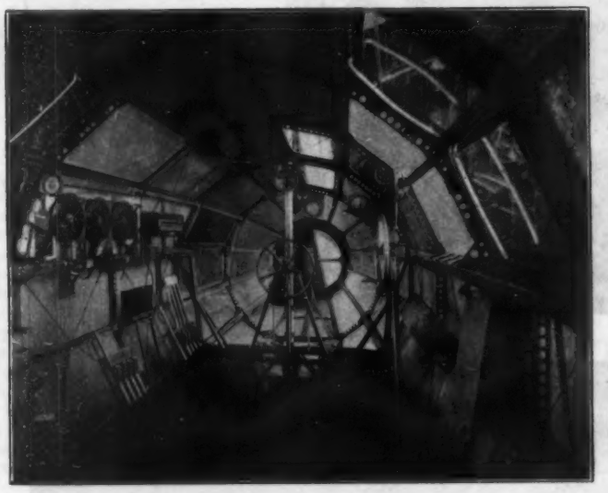


FIG. 22. CONTROL AND NAVIGATING COMPARTMENT OF FORWARD CAR.

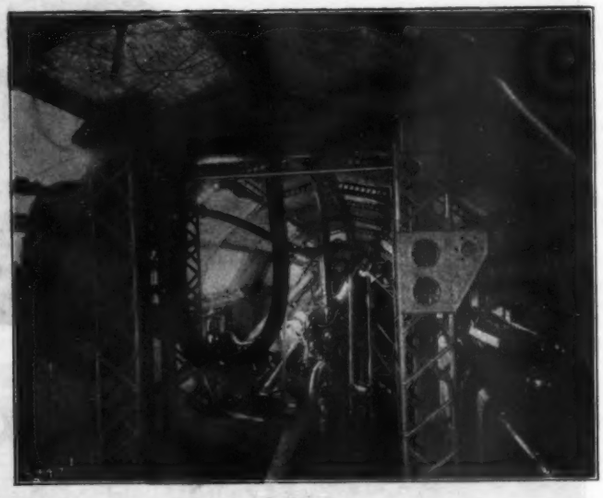


FIG. 23. INTERIOR VIEW OF WING MACHINERY CAR LOOKING AFT.

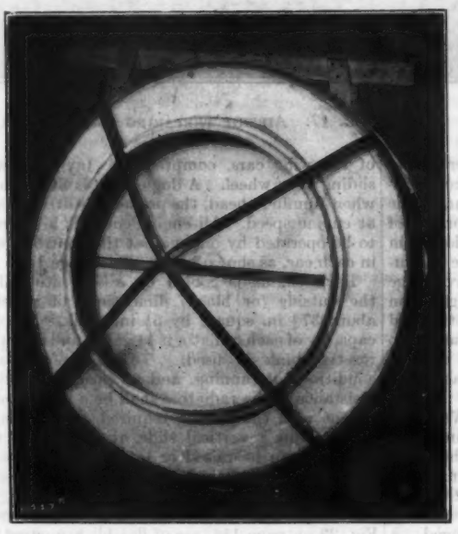


FIG. 24. AUTOMATIC GAS VALVE.

FIG. 25. MANŒUVRING GAS VALVE.

efforts. Messrs. Vickers' mast mooring gear, however, renders the flight and landing of rigid airships independent of the weather conditions, and necessitates the employment of only such men (about ten in number) as are required to operate the mechanical devices employed. In principle, the gear consists of a tall steel mast, or tower, of such a height that, when the airship is attached by the nose to the mast, she rides on an even keel at a height of upwards of 100 ft. above the ground. The top portion of the masthead, to which the vessel is attached, is arranged to rotate, so that the ship, when moored, may always lie head on to the wind. A mooring mast of this type, suitable for rigid airships, was made by Messrs. Vickers, erected at the Pulham Airship Station, and used for a comprehensive series of mooring tests carried out with R. 24, one of the early British rigid airships of the R. 23 class. We illustrated and described the arrangement on page 759 of our one hundred and seventh volume. In the improved design of mooring tower, intended for use with passenger-carrying airships, a lift has been provided to facilitate the embarkation of passengers, who pass from the top of the tower through a flexible corridor into the nose end of the ship, from which a passage-way leads into the passengers' quarters. Connections are also provided from pipes led up the tower to corresponding pipes on the airship, to enable gas, fuel and water ballast to be pumped up to the ship whilst moored. This system of mooring appears to offer important advantages for commercial airships, as the latter can be moored to the tower in any wind the speed of which is less than that of the ship, by employing only a few men.

Having now completed our description of the R. 80, it may be interesting to call attention to some of the special features of the design, and to compare them with the earlier airship, R. 33, of which the sister ship, the R. 34, was illustrated and described on page 87 of our one hundred and eighth volume. One important point is the improvements made in the hull joints and girders which enable the string netting employed on R. 33 and other ships to be dispensed with. This netting is very liable to be affected by climatic conditions and consequently requires continual adjustment to maintain it at the correct tension. Its abolition, therefore, considerably reduces the difficulty of maintenance, and at the same time, effects a useful saving in weight. New methods of manufacture have also enabled the gasbags of the R. 80 to be made lighter and cheaper than those of the R. 33, and also less permeable to gas. A considerable increase in aerodynamical efficiency has been obtained in the R. 80 by improvements in the form of the cars. The head resistance of these cars having been reduced by over 60 per cent. in comparison with those of the R. 33. The use of the fine nose of the control car as an observation station for the navigating officer is also an important feature of the design of the later ship, giving greatly improved facilities for ground work in comparison with other designs. Improvements in the structural design of the cars have also enabled the weight to be cut down to less than half those of R. 33, while the strength and rigidity have been increased. Consequently, it has been possible to provide more roomy cars, the beam of the control car being 8 ft. in R. 80, as compared with 6 ft. in R. 33. The special type of car buffer bag and buoyant covering used in R. 80, enables a very large displacement to be obtained when floating on the water. This feature reduces the risk of bursting the bags to a minimum, and also enables the ship to alight on the water without damage and without partially immersing the cars. Great care has been devoted to the arrangement and installation of the controls. A special advantage is gained by running all controls up to the hull through a main access conduit, thus protecting them completely from the weather, while enabling them to be examined in safety and comfort while the vessel is in flight. The tubular engine-bearers above referred to and illustrated in Fig. 19 on Plate XVII, while giving a degree of rigidity at least equal to those of ordinary design, have the advantage of entirely eliminating the risk of accumulation of petrol fumes and oil, and also enable visual examination of the crankcase and big-end bearings to be readily carried out without disturbing the engine or its seating. Attention should finally be drawn to the improved design of sliding radiators. In the R. 33 the gallows supporting the radiator above the car was a fixture, the head resistance of which was by no means negligible. This arrangement has been replaced in the R. 80 by the neat internal slides shown in Fig. 19 on Plate XVII, and in Fig. 23 on page 144, and, as there are no externally projecting supports, the head resistance due to the radiator depends only upon the amount of surface exposed becoming zero when the engine is stopped so that the radiator can be completely withdrawn into the car.

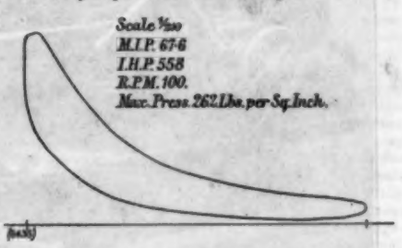
From the report on the preliminary trial flight, which was carried out from Walney Island, Barrow, on the 19th instant, we understand that the airship was taken out from its shed in decidedly unfavourable weather conditions, the wind velocity at the time being 15 knots. The operation was, however, carried out safely by a large number of Messrs. Vickers' workmen assisted by some seamen from H.M. submarines and some members of the Royal Air Force. The general view of the vessel reproduced in Fig. 17, on page 143, which was taken soon after the ship had left the shed, clearly shows what a large amount of man-power is required for handling an airship under existing conditions. The ship left the ground and rose to a height of 3,000 ft., afterwards proceeding out to sea where various manœuvres were carried out to test the stability and control, and to ascertain her performance generally. No attempt was made to determine the maximum speed attainable, but the speeds actually reached were regarded as quite satisfactory, as also were the stability and control. In turning, the R. 80 showed marked superiority over previous designs. The flight was continued for approximately two hours, after which a landing was effected safely in a wind blowing at 17 knots, and the ship was replaced in its shed without difficulty. The final speed trials will not take place for some few weeks, as the landing and mooring gear, above referred to, is now being fitted.

CRANES AND TRANSPORTERS.—Messrs. Sir William Arrol and Co., Limited, of Parkhead, Glasgow, and 56, Victoria-street, Westminster, are so well known as one of our leading builders of cranes and other lifting and transporting machinery, that it hardly seems necessary to call attention to their activities in this class of work. The new catalogue which the firm has recently issued is of such merit, however, that we are glad to make an opportunity to call attention to it. The catalogue takes the form of a substantial volume in small quarto of 250 pages, and contains illustrations and descriptions of the very large variety of cranes and transporters which the firm builds, as well as similar information relating to their hydraulic pumps, gas retort charging machinery and other allied lines of work. The volume is excellently produced on art paper throughout, and the illustrations reach a high order of merit. The book should form a valuable work of reference for any engineer concerned with the moving of material, and is more likely to find a place on his book-shelf of technical works than in his catalogue files.

PERSONAL.—The directors of Messrs. Richard Hill and Co. (1899), Limited, Middlesbrough, have elected Mr. James Rider as managing director in succession to the late Mr. Frederick Bowes. Mr. Rider was for several years manager of the Cleveland Wire Mills of Messrs. Dorman, Long and Co., Limited, and afterwards for five years manager to Messrs. Richard Johnson and Nephew, Limited, of Manchester.—We are informed that Mr. R. W. Wickham has retired from the board of Robert Heath and Low Moor, Limited, and that the Rt. Hon. the Earl of Harrowby has become chairman of the company. The total issued share capital of the Madeley Coal, Coke and Brick Company (1905), Limited, has been purchased by Robert Heath and Low Moor, Limited, and that company has disposed of one-half of the shares to Brunner, Mond and Co., Limited. The new board of the Madeley company will consist of directors nominated by both concerns. We also understand that other important arrangements have been agreed to in regard to the supply of fuel to Brunner, Mond and Co., Limited, by Robert Heath and Low Moor, Limited, and the Birchenwood Colliery Company, Limited. Mr. William G. Turner, Chief Assistant Engineer, Newcastle and District Electric Lighting Company, Limited, has been appointed Borough Electrical Engineer to the County Borough of Southampton.—Mr. E. T. Ruthven Murray has resigned his appointment as General Manager and Engineer to the North Metropolitan Electric Power Supply Company, to engage in private practice as a consulting engineer. He continues his connection with the North Metropolitan Electric Power Supply Company as constructional engineer. His address will still be Manor House Offices, Finsbury-park, N. 4.

GAS ENGINES DRIVING ELECTRIC GENERATORS AND BLOWERS.

IN our issue of October 31, 1919, page 576, we described at length a series of large gas engines which were being built by Messrs. Vickers Limited, at Barrow-in-Furness for the Appleby Iron Company, and we are now able to give some test results obtained during the week's guarantee trials of the first of these engines which was installed for supplementing the supply of current to the steel works at Frodingham. The test figures compare favourably with those obtained with somewhat similar but smaller engines of German make in the same station. In all eight of these large engines are being installed. Four of them will be used for power production in connection with the electrically-driven rolling mills and other equipment of the new works at Appleby for producing steel plates. The remainder will be used for blowing the new blast furnaces under construction at the same place. As particulars of the tests of such engines are not often published, we are glad to be able to give below the recorded results, together with the



sample indicator card reproduced above. The trials showed that the gas distribution was particularly satisfactory, and in these times it is also of interest to note that the engine was completed well up to schedule date. At the conclusion of the trial the engine was accepted, and was left running on load. A ninth engine of the same size and type, with cylinders 43·3 in. diameter and 47·3 in. stroke, and capable of developing power for a constant output of 1,200 k.w. at 100 r.p.m., has recently been ordered by the Appleby Iron Company. The speed of this engine will, however, be reduced to 80 r.p.m., as it will be used for blowing purposes. In the tests under discussion the load varied from 480 k.w. to 1,310 k.w., and the engine adjusted itself satisfactorily to the duty at all loads. The following are the figures observed:—

Gas Consumption.—Average results—

Full load	9,350 B.T.U. per b.h.p. hour.
Three-quarter load	11,600 B.T.U. per b.h.p. hour.
Half load	12,500 B.T.U. per b.h.p. hour.
Compression pressure	137·5 lb. per square inch.
Maximum pressure	264 lb. per square inch.
Mean indicated pressure	65·5 lb. per square inch.

The amount of lubricating oil used for the engine varied from 3¼ gallons to 4 gallons per eight-hour shift.

The total longitudinal expansion of the engine, measured at the end of the rear baseplate, was ¼ in. The total expansion from the centre line of crankshaft to end of rear piston rod was $\frac{3}{16}$ in. The temperature of the exhaust was taken in the first bend after the exhaust casing and registered 813 deg. F. at full load, and 790 deg. F. at three-quarter load.

QUEENSLAND'S COAL PRODUCTION.—The annual report of the Queensland Department of Mines states that the total quantity of coal raised in Queensland last year was 931,631 tons, of a value of 614,307*l.*, this being as compared with the 1918 yield, a decrease of 51,562 tons in production, but an increase of 42,002*l.* in value. There were increases both in quantities and values on the Darling Downs, at Maryborough, Rockhampton, and in the northern district, while Clermont recorded a lessened output but a rise in values. There were 48 collieries in operation in Queensland, of which 26 were in the Ipswich district.

THE LATE MR. ARTHUR EDWARD BENNETT.—We regret to have to record the death, which occurred suddenly at "Redlands," Toller-road, Leicester, on the 8th inst., of Mr. Arthur Edward Bennett, who was managing director of Messrs. Webster and Bennett Limited, Northey-road Works, Poleshill, Coventry. Mr. Bennett had been connected with the firm for about twenty-five years, during which period his relations with the employees had been of the happiest nature, while his business capabilities were generally recognised. Mr. Bennett was elected a member of the Institution of Mechanical Engineers in 1902; he was also a member of council of the Machine Tool Trades' Association. At Leicester he was prominently associated with the local Rugby football club.

HEXAGON TURRET LATHE.

CONSTRUCTED BY MESSRS. ALFRED HERBERT, LIMITED, ENGINEERS, COVENTRY.

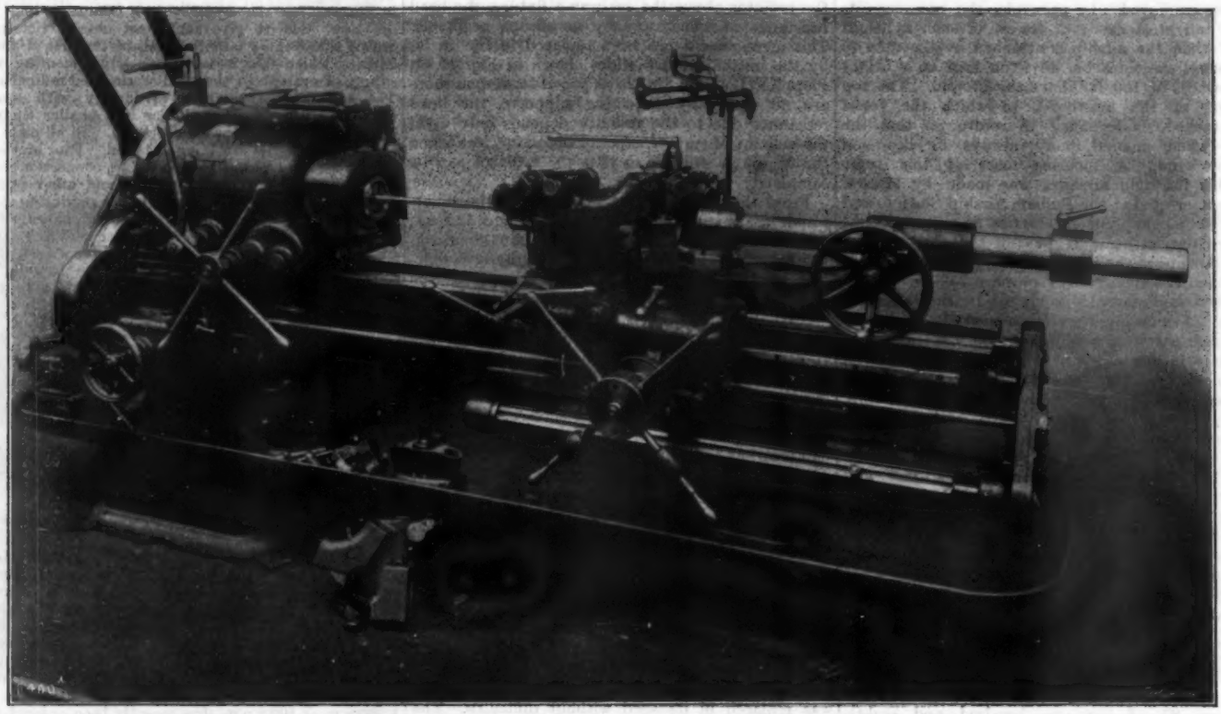


FIG. 1.

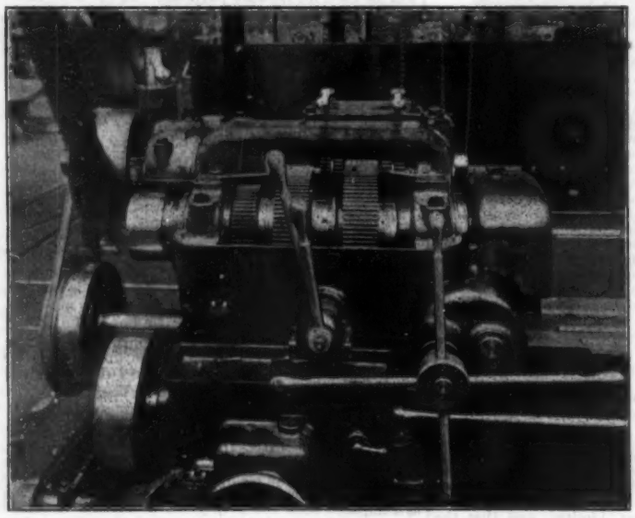


FIG. 2.

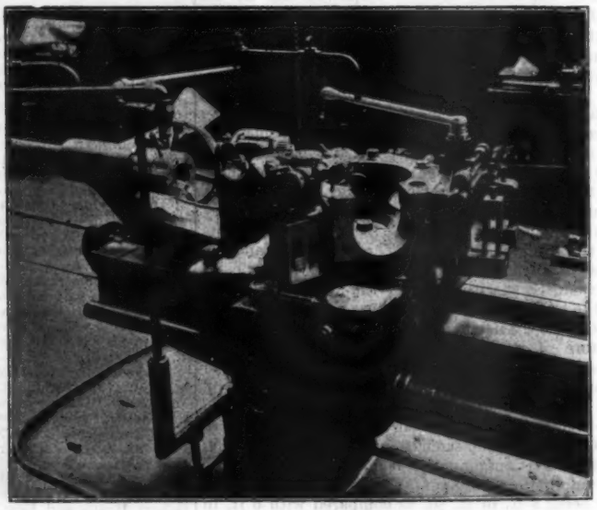


FIG. 3.

IN Figs. 1, 2 and 3 above we give illustrations of a new pattern of hexagon turret lathe brought out by Messrs. Alfred Herbert, Limited, Coventry. This particular machine is known as the firm's No. 13, and it possesses several special features. It is designed expecially for bar work, and all movements, wherever possible, are operated by power so as to relieve the operator of the heavy work.

As illustrated in Figs. 1 to 3, the machine is adapted for machining crown or roof stays, but the attachment for this work is additional and can be quickly removed in order to accommodate more ordinary jobs. It will turn out 1½ in. steel stays 24 in. overall from the steel bar at the rate of one every 3¼ mins., turned and screwed complete. Hexagon-head stays of the same diameter and 22 in. long, can be finished from forgings at the rate of one in five minutes.

The thread diameters and the central clearance portion are machined by the usual roller steady turning tools. The ends are threaded by two Coventry die-heads arranged in tandem. The rear one is mounted as will be seen from our illustrations, on a long ram which can be adjusted to suit the length of the stay. In order to ensure the two die-heads being in continuous pitch, a locating device is fitted in the ram-carrying arm, so that when the rear die-head is returned to the cutting position it registers correctly with the front one. In order that the rear die-head may run right up for short stays, one face of the turret is cut away, as shown in Fig. 3. The hand-wheel on the carrying-arm serves to withdraw the ram when it is necessary to revolve the turret.

When used for ordinary lathe work the ram and bracket can be removed, and the cut-away face is then mounted with a standard die-head in a flanged holder with a spigot fitting the recess.

The gear-box is shown in Fig. 2. Sixteen speeds are arranged with a single pulley-head. Four speeds are secured by the two levers over the box, and these are compounded with changes worked by the two levers in front of the box. The levers operating the sliding gears are interlocked to prevent two sets engaging simultaneously. The sliding gears are heat treated chrome-nickel steel. The main spindle gear is of high tensile steel. The reverse motion to the spindle is obtained by spur-gearing within the head-stock. The whole of the head-stock gears run in an oil bath. The large pilot handle, in front of Fig. 2 is for operating the double toggle bar gripping mechanism through gearing. The chuck-closing mechanism is protected by a good guard.

The feed box is under the head-stock, and is provided with a dial indicator. A small lever on the front of the feed box is for reversing the feed. The

vee belt and pulley at the end of the head-stock drives the back shaft to enable the turret to be traversed along the bed by power. Fig. 3 shows the back apron containing gearing for this movement, and also for rotating the turret by power. The turret slide is provided with felt wipers. The lubricant is delivered to the work by two pipes supplied from a reservoir in the left-hand leg, by a Coventry pump. The second pipe is for the supply for the back die-head.

A steel rule is fixed to the front shear of the lathe

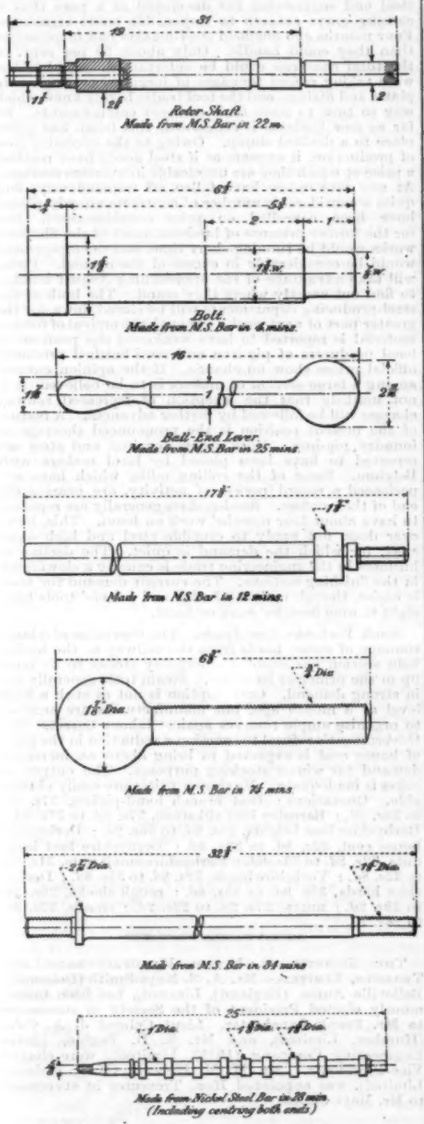

Rotor Shaft.
Made from M.S. Bar in 22 m.
Bolt.
Made from M.S. Bar in 4 mins.
Ball-End Lever
Made from M.S. Bar in 25 mins.
Made from M.S. Bar in 12 mins.
Made from M.S. Bar in 7½ mins.
Made from M.S. Bar in 34 mins.
Made from Nickel Steel Bar in 31 mins.
(Including centring both ends)

FIG. 4.

bed, and a hexagonal stop-bar below the apron provides a positive stop for each face of the turret. When the turret is being traversed by power the pilot wheel remains stationary. It is impossible for the power feed to engage while traversing by hand, and overrunning when traversing by power is likewise prevented. The lathe will take bars up to 2¾ in. in diameter, the longest possible length of work being 36 in. The single pulley runs at 500 r.p.m., giving spindle speeds ranging from 20 r.p.m. to 500 r.p.m.

Figs. 4 to 10 show some examples of work done with this tool. These are self-explanatory, and need little remark. Attention should be given to the times taken on these jobs, which show the machine to be capable of turning out a wide range of work at excellent rates.

THE SWEDISH STATE RAILWAYS IN 1919.—According to an official statement, the expenses of the Swedish State railways in 1919 exceeded the receipts by 11·07 million kroner.

INDUSTRIAL NOTES.

THE Ministry of Labour state that employment in June continued good in most of the principal industries. The percentage unemployed among workpeople (skilled and unskilled) covered by the Unemployment Insurance Acts was 2·62 on June 25, as compared with 2·68 on May 28, and the percentage unemployed among the members of certain trade unions (mainly of skilled workpeople) from which statistics are obtained was 1·2, as compared with 1·1 in May and 1·7 in June, 1919. The number of men and women on the Live Registers of the Employment Exchanges was 287,003 at June 25, as compared with 304,907 at May 28. While employment continued at a high level in most of the principal industries, there was still a depression in the leather and boot and shoe trades; the cotton weaving industry continued slack owing to the decline in the Eastern market; and the linen trade, particularly in Ireland, continued to suffer from lack of raw material.

The number of trade disputes reported to the Department as beginning in June was 183. In addition, 95 disputes which began before June were still in progress at the beginning of the month. The total number of workpeople directly or indirectly involved in these disputes, new or old, was about 128,000, as compared with about 138,000 in the previous month and about 548,000 in June, 1919. The estimated aggregate duration of all the disputes during the month was about 1,257,000 working days, as compared with 1,169,000 days in May, 1920, and 3,836,000 in June, 1919.

In the industries for which statistics are available, changes in rates of wages reported to the Department as having been arranged to come into operation in June, with effect either from that month or from earlier dates, resulted in a total increase of nearly £570,000 in the weekly wages of over 2,600,000 workpeople. The principal bodies of workpeople affected were railway servants, engineers and shipbuilders, woollen and worsted operatives, and workpeople in the printing and bookbinding trades. Changes in hours of labour affected nearly 8,000 workpeople, for whom there was an average decrease of nearly 4½ hours in the normal working week.

The average level of retail prices (including those of food, clothing, fuel and light, &c., as well as rents) on July 1, as indicated by the statistics prepared by the Ministry of Labour, was about 152 per cent. above the level of July, 1914. For food alone the average increase was 158 per cent. These statistics relate to commodities of pre-war working class consumption, and the same quantities and, so far as possible, the same qualities of each article are taken at the present time as before the war.

The executive of the Miners' Federation of Great Britain, who were received at the Board of Trade last Monday, were informed by Sir Robert Horne that the Government had come to the conclusion that the miners' claims could not be acceded to. It will be remembered that the miners demand the cancelling of the 14*s.* 2*d.* per ton increase in the price of coal added in May last, together with an advance in wages of 2*s.* per day to workers over 18, of 1*s.* per day for those between 16 and 18, and 9*d.* per day to those under 16. Sir Robert stated that the cost of living, since the war, had risen by 152 per cent., whilst the wages of all colliery workers had increased by 154 per cent. or even 157 per cent. Further, the miners were supplied with coal at exceedingly low prices, and therefore the figure which represented the increased cost of living was higher in reality to the ordinary individual than it was to the miner. Compared with the above increase in the wage of the colliery workers, the wage of the skilled engineer had gone up by 132 per cent.; and last week, the Industrial Court had decided that the condition of things at the present time did not warrant any further increase in the engineers' wages. Dealing with Mr. Smillie's remark that there would be a surplus profit on the coal trade at the end of twelve months from now of 66,000,000*l.*, Sir Robert stated that our export prices might be affected very soon by German exports. If Germany kept her pledges, the amount of coal she would send to France would be very much increased, and when France obtained that German coal, it was clear that the demands upon our market would be lower, and France would not be willing to continue paying the price she had paid in the past. There was, also, the question of increasing competition of other countries in the markets of Europe. If the miners' proposals were adopted, to the effect that all surplus profit be divided roughly as to one-half in miners' wages and one-half in reduction of price, the coal trade would be contributing nothing to the Exchequer in the shape of excess profits duty, except the mere fraction obtained out of one-tenth of the surplus which, under the provision of the Coal Emergency Act, at present goes to the coalowner, an infinitesimal amount compared with what the coal trade really ought to contribute. The surplus profits, if realised, constitute a windfall from the export price of coal. In regard to the price of coal to the domestic consumer, Sir Robert said that since the latter had been placed in the same position as the factory owner, the elaborate staffs, which were previously required for insuring proper and equitable distribution, had been disbanded. The miners' proposal would mean that the Government should subsidise the coal supply to the domestic consumer; this would be a step backwards.

It is understood that a conference of the miners will be summoned for August 12, to consider the Government's reply.

The preliminary agenda for the Trades Union Congress which opens at Portsmouth on September 6, has been issued. One point to come before the Congress will be the proposal to set up, in place of the Parliamentary Committee, a General Council to co-ordinate industrial movements, promote common action by trade unions on general questions, and, where disputes are threatened, to use its influence to promote a settlement. There is a motion in the name of the Parliamentary Committee to amend the standing orders and give effect to the scheme. The General Council, it is proposed, shall consist of 30 members elected to represent 17 groups. Among the general resolutions is one by the Boilermakers expressing the opinion that the method of furthering Congress resolutions by deputations to Ministers is becoming less effective, and is now almost obsolete. The resolution instructs the Parliamentary Committee to consult the Labour Party Executive on questions requiring political action and the unions concerned on matters of an industrial character. The Engineers' Amalgamation will propose a resolution declaring that responsibility for unemployment should be borne by industry, and the Dock, Wharf, and Riverside Workers' Union will propose the imposition of a levy on each responsible industry to maintain its own unemployed. The Amalgamated Union of Labour is to put forward a proposal to provide a minimum income for all by the nationalising of 20 per cent. of all incomes into a central pool, and its equal distribution in the form of a minimum subsistence allowance to every man, woman, and child, irrespective of earning capacity, and without qualification. On the cost of living the Ship Constructors and Shipwrights' Association proposes that all unions should combine as one unit in demanding a substantial reduction, and that, failing immediate action by the authorities, an alternative demand should be put forward for a 50 per cent. increase on present earnings, or a minimum of 6*l.* 6*s.* per week. The Central Ironmoulders' Association proposes that Congress should instruct the Parliamentary Committee to call for a ballot vote from all affiliated unions on the question of downing tools unless the Government take steps to reduce the cost of foodstuffs immediately by 50 per cent. The Boilermakers will again bring forward the question of the 44-hour week and call on Congress for a pledge to support affiliated unions in legitimate industrial efforts to put the proposal into practice.

The Industrial Court issued its award last week in an arbitration affecting workers engaged in or about lead and zinc mines in Central and South Wales, North Wales, Shropshire, the Isle of Man, Cumberland, Westmoreland, Lancashire, the east side of the Pennines, Alston district, and the North Riding of Yorkshire. The workers claimed an increase of 2*s.* per shift, or 12*s.* a week for men, and 1*s.* per shift, or 6*s.* for boys under 18, and the Court decided that men of 18 years of age and over should receive an advance of 1*s.* per shift or 6*s.* per week, and youths under 18 years an advance of 6*d.* per shift, or 3*s.* per week, as from June 2.

A claim by the National Union of Railwaymen for an increase of 10*s.* per week to women, girls, and boys employed in railway workshops throughout Great Britain was considered by the Industrial Court, which in an award issued also last week, decided that it had not been established.

House plans representing 2,077 houses were submitted to the Ministry of Health during the week ending the 17th inst., and plans for 2,382 houses were approved. The total number of houses represented in all the plans now submitted is 235,643, and in the plans approved 221,778. During the week tenders were submitted for 3,926 houses. Tenders for 2,584 were approved, bringing the total number of houses in tenders submitted to 147,216 and in tenders approved 128,812. Contracts have been signed for 74,517 houses. At the end of June, 3,622 houses had been completed with the exception, in some cases, of painting. Building of 23,376 other houses had commenced, of which 6,763 were roof high. Flats number-

ing 275 have been provided by the conversion of houses in London.

The Ministry of Health state that the shortage of labour is growing more acute. For every 15 skilled workmen now employed on housing schemes, work is available for 12 more. The total of skilled men employed is 15,100, and 12,192 more are required. The greatest deficiency is of bricklayers, of whom 7,031 are employed and 7,101 more are needed for immediate work. The need of men is felt in all districts, but most severely in the Northern and Midland districts.

In our issue of June 18, page 835, we stated that an armistice of six weeks, ending on July 24, had been decided upon in the recent Sheffield strike, the National Amalgamated Union of Enginemen and Firemen, acting by itself and apart from any other union, having to submit to the Industrial Court the main question in dispute, namely, as to whether the men concerned should be paid by the hour (or week) or by the shift. The Court has now issued its decision, which is in effect what the five loyal unions (see ENGINEERING June 4 and 11) had under award 84; in other words, the men concerned shall work on the three eight-hour shift system. The direct result of this is that about 600 more men will find employment in the Sheffield industries; it will also do away with the overtime which some men were working.

According to a statement by Sir Eric Geddes, the railway companies in the United Kingdom now number 253. The number of railway directors is approximately 1,350, and their fees amount to about 200,000*l.* per annum. The dividends payable for 1919 amounted to 36,500,000*l.*, exclusive of 12,500,000*l.* for interest on debenture stock and loans. The number of workpeople of all grades employed is about 700,000, and the total wages bill is approximately 161,000,000*l.*

We referred on page 120 *ante* to the decision of the Industrial Court against the 6*d.* per hour advance claimed by the engineers. A meeting was held in Manchester last Sunday of the Amalgamated Engineering Union, when the following resolution was passed unanimously:—

"1. That this meeting of the A.E.U. in the Manchester district declares that the Court of Arbitration has abused the confidence placed in it by the unions concerned, and by its recent decision has clearly demonstrated that it is not an independent court, but acts in accord with the instructions given it by its capitalistic masters, therefore we resolve to use every constitutional means to improve the status of the operative engineers so as to meet the abnormal conditions at present prevailing.

"2. That this meeting demands that our Executive Council immediately call into operation a national conference in accordance with the new rules of the A.E.U.

"3. We strongly recommend the national conference to adopt the restriction of all overtime throughout the industry, the said restriction to be rigidly enforced on all classes of work, irrespective of whether it be of a productive nature, or breakdowns, or repairs to plant, or maintenance, or repairs generally, except in cases involving the loss of life and limb, the districts throughout the United Kingdom to be instructed immediately to carry out this recommendation.

"4. That this meeting also recommends the national conference to declare that all members of the A.E.U. shall work on the system of plain time work (which means the suspension of all piece work, bonus, or any other system of payment by results) until a satisfactory adjustment of the wages grievances is arrived at, thus spreading production over a greater period of time."

The last report to be issued by the Steam Engine Makers' Society, dated the 12th inst., states that the membership is 30,000, the branches number 226, and the capital amounts to £310,000. The report contains the reprint of a letter addressed by the general secretary, Mr. Dawtry, to the executive council of the society, stating that he does not wish to accept office as a member of the Executive of the Amalgamated Engineering Union; he adds that he is quite unable to subscribe to or to support a scheme of amalgamation which completely absorbs each and every individual union concerned, since he believes that all the objects to be achieved were within reach of every separate society acting individually. He views with serious misgiving many of the methods and much of the policy now being followed in the name of trade unionism; he feels that these methods and policy are supported by a very active section of each of the individual unions forming the amalgamation, but, in his opinion, a minority, the majority having given their sanction to the amalgamation in an indirect manner, through their inactivity and apathy. He also views with alarm and profound regret the treatment meted out from time to time, and quite regardless of experience gained and honest service rendered, to trade union officials who mayconsider it their duty occasionally to express opinions contrary to those of this said active section. Facts such as these make him anxious as to the future of trade unionism. Mr. Dawtry has been a member of the society for 36 years, for 16 of which he has acted as general secretary. Mr. Blinkhorn, the assistant general secretary, also retires from his present position under the amalgamation scheme.

An award of the Federation of Engineering and Shipbuilding Trades, dealing with demarcation of work between heating and domestic engineers and plumbers, recently delivered, found that the plumbers had failed to establish any claim to the exclusive right to fix all pipes and fittings in hard metals used in connection with ventilation, heating, warming, laundry, cooking and general hot and cold water domestic (or other) supplies or services. The award stated "that all lead work in connection with hot and cold water domestic (or other) supplies and services shall be plumber's work; that all other work in connection with ventilation, heating, warming, laundry, cooking and general hot and cold water domestic (or other) supplies and services, in which iron, brass, copper or other similar hard metal piping is used, may be done by the heating and domestic engineers, fitters, or by plumbers."

"GERMANY'S POST-WAR INDUSTRIAL PROBLEMS."

TO THE EDITOR OF ENGINEERING.

SIR,—Having been away from London during last week-end, I have only to-day seen the letter signed "Lungazi" in your issue of the 23rd inst. I may take the last paragraph of that letter as a query, and may add that this is answered fully by an article in *Stahl und Eisen* of the 8th inst. The article in the German journal, after referring to the mining industry of Germany and to that of the Ruhr district in particular, says that in order to meet the requirements, "increased production is needed, and that this can only be secured by increasing the working time at the coalfields is shown by the fact that in the Ruhr coal mines alone there are now, in round figures, 70,000 more men actually employed than during the last peace year, notwithstanding which fact the output is now only 60 per cent. of that of 1913."

Yours faithfully,

July 26, 1920. "READER."

THE RIEGGER HIGH VACUUM GAUGE.—A new high vacuum gauge of the Knudsen type, which is now considered the most reliable, has been devised by H. Riegger, and is made by Siemens and Halske. The Knudsen gauge measures the repulsion set up between two parallel strips of platinum by the molecular bombardment of the residual gas in the vessel being tested. One strip is heated and fixed, while the other is suspended as a vane. What is measured is, therefore, a radiometer effect, and Riegger gives his vane the shape of a small mill-wheel, which he makes by slitting a disc radially and setting the sectors at 45 deg. to the plane of the disc. The wheel is suspended by a tungsten wire, the rotation of the wheel being observed on a graduated aluminium ring fixed to the wheel. Above the wheel is stretched the electrically-heated platinum strip. The rotation of the wheel can be damped by means of electromagnets near it; for the most accurate determinations the damping is dispensed with. The apparatus is mounted in a glass vessel and in order to liberate the gas retained by the glass and the metallic parts a small electric furnace can be lowered over the vessel, and the glass can be heated to 420 deg. C. The largest rotation of the wheel is obtained when the vacuum is about 0·01 mm. of mercury; as the evacuation is increased, the pressure curve becomes more and more a straight line; very high vacua can be determined.

A 10,000-TON FLOATING DOCK FOR SCHIEDAM.—The New Waterway Shipbuilding Company have recently installed at their Schiedam shipyard, near Rotterdam, a floating dock, having a lifting capacity of 10,000 tons, built by Messrs. Swan, Hunter and Wigham Richardson, Limited, Southwick, near Sunderland. The dock was ordered by Messrs. Furness, Withy and Co., who have the chief interest in the New Waterway Shipbuilding Company. It was built during the war and was at once commandeered by the British Admiralty and towed to the Invergordon naval base in the Cromarty Firth. The dock is 500 ft. long overall, 104 ft. wide outside and 75 ft. wide inside the walls. The pumps, by Messrs. Gwynnes, Limited, London, are driven electrically, the current being taken from a power station on shore. The dock is of the bolted sectional type, built of three sections, each of which is a complete box dock; they are bolted together. When self-docking is required for painting or repairs, the three sections are disconnected and then any two of them can lift the third section out of the water. When the Admiralty released the dock, it was taken to Schiedam by the International Tug Company, Rotterdam. The towage was hampered by bad weather and head winds, but in spite of such unfavourable circumstances it was accomplished successfully. Within three days of arrival at Schiedam, the dock successfully lifted a ship and has since continued to be busily employed.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

The Latest Big Gun.—During the visit of Earl Beatty, the Lord Mayor announced that there is in Sheffield a gun that can out-distance the German "Big Bertha." It transpires that this gun is being built at the Sheffield works of Messrs. Vickers, Limited. It is 80 ft. long, and can throw an 8-in. shell between 70 and 80 miles. The gun will require re-lining at frequent intervals, owing to the extraordinarily high velocity of the projectile.

Iron and Steel.—The downward trend of business in steel and engineering has developed at a pace that is causing grave concern to responsible trade organisers. Four months ago Sheffield steel-makers had more orders than they could handle. Only about 30 per cent. of the total enquiries could be entertained. Shipbuilders were taking record tonnages of forgings, castings, ship plates and fittings, and the tool trades hardly knew which way to turn to meet their contract commitments. So far as new business is concerned, this boom has given place to a decided slump. Owing to the excessive cost of production, it appears as if steel goods have reached a price at which they are unsaleable in overseas markets. At any rate orders have fallen off tremendously, and quite a considerable number of contracts already placed have been cancelled on price considerations. But for the former pressure of business, most of the Sheffield works would be running short time, and unemployment would be considerably in excess of the normal. Firms will take advantage of the approaching August holiday to find out exactly where they stand. The bulk of the steel-producing departments will be closed down for the greater part of next week. Though the arrival of foreign material is reported to have weakened the position of local producers of pig-iron and semi-finished products, official prices show no change. If the opinion current among a large section of makers is to be believed, it is not unlikely that the inception of increased railway charges will be followed by further advances. A feature of the present position is the pronounced shortage of foundry pig-iron. More orders for iron and steel are reported to have been placed by local makers with Belgium. Some of the rolling mills, which have experienced a record period of activity, are nearing the end of their orders. Steel-makers generally are reported to have about four months' work on hand. This, however does, not apply to crucible steel and high-speed steel, for which the demand is quiet. The decline of business in the engineering trade is causing a slowing-off in the finishing sections. The current demand for tools is easier, though makers of edge and joiners' tools have eight to nine months' work on hand.

South Yorkshire Coal Trade.—The liberation of a large tonnage of steam hards from the railway to the household section has enabled emergency stocks to be built up in the principal localities. Steam fuels generally are in strong demand. Consumption is not at such a high level as a month ago, but manufacturers are anxious to organise ample reserves against labour unrest. The Government's refusal to sanction a reduction in the price of house coal is expected to bring about an increased demand for winter stocking purposes. The output of cokes is inadequate. Maximum prices are easily obtainable. Quotations: Best branch hand-picked, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best silkstone, 37*s.* 2*d.* to 37*s.* 8*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire best large nuts, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; rough slacks, 28*s.* 2*d.* to 29*s.* 2*d.*; nutty, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

THE SOCIETY OF MOTOR MANUFACTURERS AND TRADERS, LIMITED.—Mr. A. S. Mays-Smith (Delaunay-Belleville Autos. (England), Limited), has been unanimously elected President of the Society in succession to Mr. Frank Lanchester. Lieut.-Colonel J. A. Cole, (Humber, Limited), and Mr. S. D. Begbie, (Aster Engineering Company (1913), Limited), were elected Vice-Presidents. Mr. H. M. Hobson, (H.M. Hobson, Limited), was appointed Hon. Treasurer in succession to Mr. Mays-Smith.

JAPANESE SHIPBUILDING.—Speaking before the Budget Committee of the House of Representatives, the Minister for the Navy, stated that Japan's building capacity was two capital ships a year. Japan's naval programme was not directed against any potential enemy, but dictated by the country's insular position, although the possibility of the dispatch of foreign strength to the Orient had not been disregarded. The present Budget, the Minister added, provided for four dreadnoughts, four battle-cruisers, and 12 cruisers and smaller craft. The cost would be 680,000,000 yen (68,000,000*l.* at par).

THE LATE MR. JOHN HEEL NICHOLSON.—We regret to have to record the death, which occurred on the 22nd inst., of Mr. John Heel Nicholson, lecturer on electrical engineering at Glasgow University. Mr. Nicholson was 40 years of age; he went to Glasgow from Aberdeenshire and had a brilliant career as a student, graduating B.Sc. He was appointed lecturer in electrical engineering in 1906, a position in which his abilities were greatly esteemed, both by the authorities of the Glasgow University and the students. During the war he served at the Air Board, London, and subsequently received the O.B.E. Mr. Nicholson had recently completed a thesis which was accepted for the degree of D.Sc., but his illness prevented his actually receiving that distinction.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Cleveland pig-iron is still scarce. Production continues quite inadequate to cope with home requirements and makers adhere firmly to their decision not to sell for abroad, but it is gratifying to learn that better supply of raw material is enabling output to be increased to some extent. An additional furnace has been put into operation at the Ormesby Ironworks of Messrs. Cochrane and Co., and is running satisfactorily on quarter blast, turning out foundry iron, and other firms may put idle plant into motion before long. It is some satisfaction to learn that August allocations to Scotland are substantially better than those for July, even though it appears that the increased allotments little more than make up for this month's cancellations of deliveries. For home consumption No. 3 and No. 1 inferior qualities of Cleveland pig are 217*s.* 6*d.*; and No. 1 is 230*s.* There are no export quotations.

Hematite Iron.—Stringency in hematite is unrelieved. Most makers are fully sold up to the end of the year, and are consequently disinclined to discuss further business. A few home and foreign sales, however, are reported. Some producers express the opinion that the recognised 5*s.* difference in home rates and quotations for the European Allies is too small. This is of little consequence at present as export demand is dull. To home customers Nos. 1, 2 and 3 East Coast brands are 260*s.*; and No. 1 is 262*s.* 6*d.*; and for shipment to France, Belgium and Italy mixed Nos. are 265*s.*; and No. 1 is 267*s.* 6*d.* Small lots of hematite have been sold to neutrals at 300*s.* f.o.b.

Foreign Ore.—Business in foreign ore is very slow. Sellers are now much in evidence, and are prepared to make considerable concessions to secure orders, but consumers are not to be tempted, declaring they have every confidence that market movement will continue in their favour. Quotations are based on 49*s.* for rubio, of 50 per cent. quality, on the 17*s.* parity freight Bilbao-Middlesbrough, so that as the latest chartering from the Spanish ore port is reported at 21*s.*, the c.i.f. Tees value of best rubio may now be given as 53*s.*

Coke.—Home and foreign demand for coke is heavy. A good home business is passing, very ample supplies meeting heavy local needs, though in some cases deliveries are hampered by truck shortage. Export trade is difficult to put through. For home purposes medium blast-furnace sort is 62*s.* 9*d.* at the ovens; and low phosphorus kind is 65*s.* 3*d.* at the ovens. Buyers freely offer 230*s.* for gas coke for export.

Manufactured Iron and Steel.—There is rather more home business passing in finished iron and steel, but foreign trade is practically at a standstill. Steel rails and fish-plates have been advanced 2*l.* per ton, but other quotations are unaltered. Principal market rates stand: Common iron bars, 30*l.*; marked bars, 32*l.*; iron angles, 30*l.* 15*s.*; steel ship, bridge and tank plates, 23*l.* 10*s.*; boiler plates, 30*l.*; steel angles and joists, each 23*l.*; channels and flats, 23*l.* 5*s.*; tees, 24*l.*; rounds and squares, 25*l.* 10*s.*; heavy steel rails, 25*l.*; fish-plates 30*l.*; soft steel billets, 25*l.* 10*s.*; hard steel billets, 26*l.* 10*s.*; black sheets, 44*l.* 10*s.*; and corrugated galvanised sheets, 56*l.*

EXHIBITIONS AT OLYMPIA AND WHITE CITY.—The Society of Motor Manufacturers and Traders, Limited announces a Commercial Vehicle Exhibition to be held at Olympia from October 15 to 23; a Motor-Car Exhibition at Olympia and the White City from November 5 to 13; an International Motor Boat and Marine and Stationary Engine Exhibition at Olympia from March 11 to 23, 1921.

POWER ALCOHOL SUPPLIES.—The Empire Motor Fuels Committee of the Imperial Motor Transport Council announces that, after consultation with the authorities concerned, it will not be possible to arrange to make supplies of power alcohol available for experimental and trial purposes for some little time. The Hon. Secretary of the Empire Motor Fuels Committee, Captain F. G. Bristow, whose office is at 50, Pall Mall, S.W. 1, has already received preliminary applications from manufacturers of engines and carburettors and owners of commercial goods vehicles, but no action can be taken with regard to them at present as the exact date for the freeing of supplies depends upon the passage through Parliament of the Finance Bill, which passed the House of Commons on Wednesday. He proposes to make a further announcement upon this matter when he is in a position to do so.

AVIATION IN ARGENTINA.—According to the review for July of the London and River Plate Bank, Limited, general interest in commercial flying increases steadily and flights to and from the interior by business men are frequent, while the various aviation companies report a growing number of sales to private individuals. It is also said that the Argentine Government has placed a large order with the representative of an American firm turning out a well-known make of machine, though no details have yet been published. Regular services cannot, however, be said to have been established between any fixed points, though the local representatives of the Handley-Page interests have announced their intention of starting in the near future a hydroplane line between Buenos Aires and Montevideo. The machines will be of a capacity sufficient for two passengers or 250 kilos cargo as the normal load.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—With the resumption of business in the West of Scotland, consumers of all classes of steel material are again calling for deliveries against contract, and a goodly amount has already been despatched. The restart has been fairly satisfactory all round, but in some establishments the workers have been slow to resume operations, which is accounted for by the great and growing desire for a longer holiday at this time of the year. Wages have been high, and in some departments the men have had a fairly hard time during the past six months; hence the wish for a rather more lengthened rest than the usual ten days. Owing to heavy repairs being necessary one or two works declared a fortnight's holiday, but everything should be in full swing by next Monday, and outputs should then be at the present-day maximum. The Clyde shipyards are very busy, and there is again a heavy demand for plates, &c., while for structural sections there is also quite a lot of business passing. The makers of black steel sheets have an exceptionally large amount of work booked, and are this week settling down to another spell of activity. The competition from the Continent is not being much feared meantime, and any lots which have come forward have only helped to ease things to a very small degree. The bulk of the production of all kinds of steel is still being consumed by the home trade, and export figures are very small indeed. Prices are firm and are not showing much sign of easing yet, although a strong opinion prevails that the present high level cannot be maintained much longer.

Malleable Iron Trade.—Conditions in the West of Scotland malleable iron trade are not unlike those in the steel industry—plenty of orders, and much pressure for deliveries. Most of the works have restarted, and everything points to a steady run being general. Here, again, the most of the output is being taken up by the home trade, but there would look to be a possibility of the export side of the business being developed a bit further in the near future.

Scotch Pig-Iron Trade.—The state of the Scotch pig-iron trade is very similar now to what it was before the holidays, and makers are being pressed for supplies, with the inevitable result that all accumulations will speedily disappear, if such has not already taken place by now. All the higher grades of iron are extremely scarce, and No. 1 foundry iron is almost unobtainable. Hematite, while a little more plentiful, is in great demand by steelmakers, who are taking in as much as they can secure. All the works are very busy on home orders, but foreign buyers are again in the market with some very respectable inquiries, which, despite the high prices which would require to be paid, would, in a number of cases, result in business were the stuff available.

Export Trade.—The export trade in steel and iron material has been of a very negligible quantity for a considerable time back, nor is there any sign of an early improvement. Certainly there are now more ships available, but with the home trade eating up almost everything produced it is difficult to see where the foreign market is to get anything. Inquiries have come along regularly, but the usual reply was "regret, cannot offer," and now the inquiry is very small indeed. The most probable reason for the latter is supposed to be due to the present high prices, and the foreign buyer is meantime holding off in the hope of a break. He has much work to place, but, having already waited long for fresh supplies, he considers it would be good policy to hold off a little longer and thus save considerably. There may be something in his contention, as there is a slightly easier feeling noticeable since the holidays, but a slump is not looked for.

THE CANDLE FLAME AS A TURBID MEDIUM.—It is well-known that light rays passing through a homogeneous medium remain invisible, but that they become visible in a turbid medium which scatters, diffracts and polarises the rays at the same time. From experiments made by Senftleben and Elisabeth Benedict at Breslau (*Kolloid Zeitschrift*, vol. xxvi, pages 97 to 100) we see that the flame of a candle or a lamp, in which carbon particles glow, acts as a turbid medium, as one would indeed expect. To get intense effects they steady and throw the narrow beam of an arc lamp on a Hefner (pentane) lamp. They found that the intensity of the scattered light increased by 300 per cent. as the angle between the incident beam and the direction of observation increased from 45 deg. to 150 deg., and that the polarisation was a maximum at 90 deg., 86 per cent. of the incident light being then polarised. The intensity of the scattered light was also greater for short waves than for long waves, and the absorption decreased therefore with increasing wave-length. Considering that the effects are due to small particles of incandescent carbon, this is rather surprising since the absorption of massive carbon is almost independent of wave-length. According to Rayleigh the absorption of light by a flame should vary inversely as $\lambda^{1\cdot4}$; but the flame does not satisfy the conditions of Rayleigh. The theory of the propagation of light through turbid media was given by G. Mie in the *Annalen der Physik* in 1908. Applying Mie's formula Senftleben finds that the glowing particles in the flame, if spherical and not too crowded, should have a diameter of 175 $\mu\mu$, and this value agrees with the polarisation data. Senftleben also deduced that there would be $9\cdot8 \times 10^{-5}$ particles of carbon per cubic centimetre of the flame. This estimate, it may be remarked, accords with that which A. Becker made in 1906 by determining the amount of soot deposited from flames. The reflective power of the pentane flame is small.

IRON AND STEEL INSTITUTE.

An invitation has been extended by the ironmasters and steel manufacturers of South Wales and Monmouthshire for the autumn meeting of the Institute to be held in Cardiff, at the South Wales Institute of Engineers. A reception committee, of which the Rt. Hon. the Earl of Plymouth, Lord-Lieutenant of the county of Glamorgan, will be chairman, Mr. Edward Steer, Vice-President of the Institute, Deputy-Chairman, and Mr. David E. Roberts, Member of the Institute, Honorary Secretary, has been formed to carry out the necessary arrangements. The provisional programme of the meeting is as follows:—Monday, September 20, 5 p.m. to 7 p.m., registration of members and issue of badges, programmes and tickets. Tuesday, September 21, 10 a.m., general meeting of members. The Council will give notice of a resolution for the alteration of bye-laws 21 and 22, relating to annual subscriptions, which is to be submitted at the annual meeting in London, in 1921. A selection of papers will be read and discussed (Nos. 3, 11, 5). Visit to Dowlais Cardiff works and Bute docks. In the evening a reception at the City Hall by the Lord Mayor of Cardiff (Councillor Geo. F. Forsdike). Wednesday, September 22, 9.30 a.m., general meeting of members. A selection of papers will be read and discussed (Nos. 9, 6, 2). Visit to Alexandra Docks, Newport, or visit to Barry Docks. Thursday September 23, visit to Ebbw Vale works or visit to Chepstow. Friday, September 24, visit to Port Talbot or visit to works at Swansea. The following is a list of the papers which, it is expected, will be submitted at the Cardiff meeting:—1, E. D. Campbell and B. A. Soule, "Notes as to Rates of Reaction in Certain Steels at 930 deg. C."; 2, C. G. Carlisle, "Electric Steels"; 3, W. Dixon, "The Electrification of the Works and Collieries of the Ebbw Vale Steel, Iron and Coal Company, Limited"; 4, R. H. Greaves and J. J. A. Jones, "Temper Brittleness of Nickel-Chromium Steels"; 5, D. Hanson and Mrs. Hilda E. Hanson, "The Constitution of Nickel-Iron Alloys"; 6, W. D. Hollings, "Variations in the Heat Supplied to the Blast Furnace, and their effect on the Fuel Consumption"; 7, K. Honda and T. Murakami, "Graphitisation in Iron-Carbon Alloys"; 8, K. Honda and S. Saito, "On the formation of Spheroidal Cementite"; 9, A. Hutchinson and E. Bury, "The Rough Cleaning of Blast-Furnace Gas at Skinningrove by the Lodge Electrostatic Process"; 10, A. McWilliam, "Indian Iron Making at Mirjati, Chot Nagpur"; 11, W. Rosenhain and D. Hanson, "Inter-Crystalline Fracture in Mild Steel"; 12, E. Schneider, "An Investigation of Various Forging Operations carried out under Hydraulic Presses"; 13, J. H. Whiteley, "Experiments on the Deoxidation of Steel with Hydrogen."

AN INTERNATIONAL CHAMBER OF COMMERCE.—About 200 American business men are now in Paris taking part with the business men of other nations in the organisation of an international chamber of commerce, says *Commercial America*. The important primary object of the organisation will be the encouragement and assistance of international trade. It is planned to do this by the removal of international friction, much of which is caused by commercial differences. While it is too early to decide how such an organisation is going to work out, it may be said in its favour that it is an organisation of business men rather than of politicians or diplomats. As such it would seem to stand a much greater chance of success than the several international political and semi-political conferences which have deliberated upon current problems to no decided purpose or result.

AMERICAN FOREIGN TRADE FLOATING EXPOSITION.—The First National Foreign Trade Floating Trade Exposition will sail for South America, and the Far East in October, with exhibits of American manufacturers, according to *The Iron Age*, New York, the purpose being to improve trade relations with these countries and reduce expenses incident to individual effort. Various lines of manufactures will be represented though only one manufacturer from each competing field will have exhibits. The ship will tarry at each port from five days to two weeks. After those primarily interested have been admitted to the ship, the general public will have access. Interpreters will be on board. A publicity man will precede the expedition. The trip will last eight months, and the following countries will be visited: Central and South America, New Zealand, British Straits Settlements, Australia, Philippine Islands, China and Japan. The exposition offices are at 50, Church-street, New York.

JAPANESE TRADE.—There are indications from various quarters that Japanese manufacturers are not finding it so easy to maintain the hold on foreign markets that they secured during the war, says *The London and China Telegraph*. In the Argentine, Australia, South Africa, and other countries there have been signs of a slump in their trade. On the other hand, they are leaving nothing undone to extend their trade abroad, and it is evident, therefore, that strong competition is to be expected from that quarter in the future. Latest information shows that they are making serious efforts to improve the quality of their manufactures. That the traders of Japan are on the alert and mean to secure their share of the world's markets may be gauged by the announcement just made that a floating exhibition of Japanese products recently left that country, among its ports of call being Lisbon and other European ports. This is one of the many other indications that Japanese manufacturers are fully alive both to the requirements as well as the possibilities of the present situation.

THE RIGID AIRSHIP "R. 80."

CONSTRUCTED BY MESSRS. VICKERS LIMITED, BARROW-IN-FURNESS.

(*For Description, see Page* 142.)

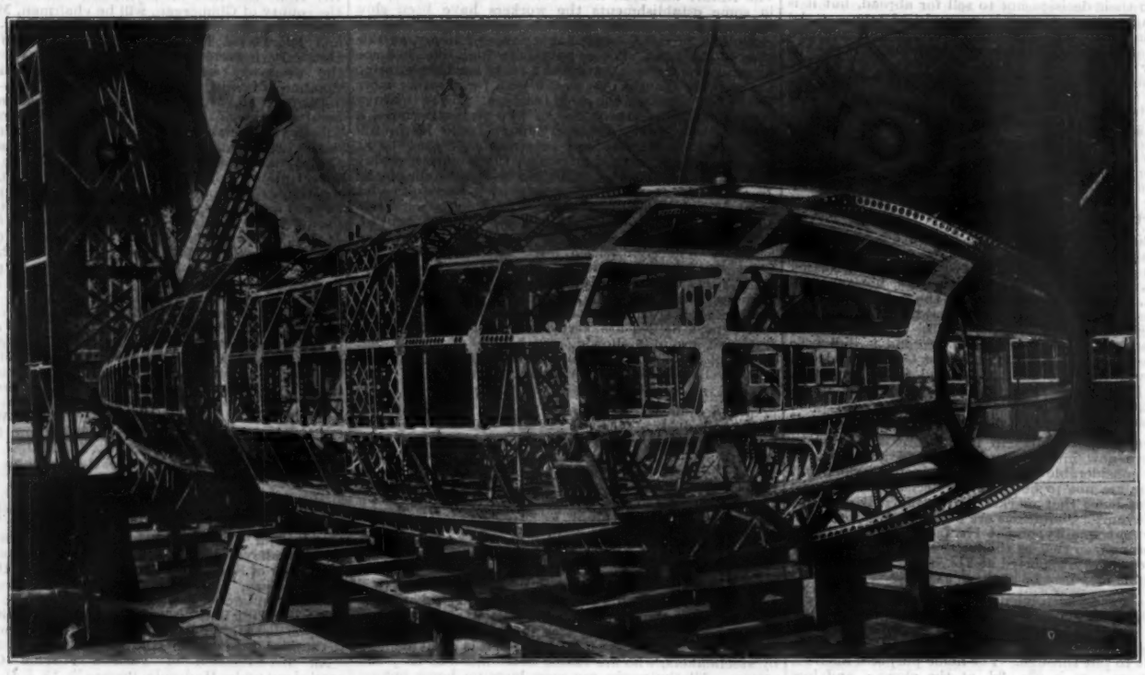


FIG. 26. FRAMEWORK OF FORWARD CONTROL AND MACHINERY CAR.

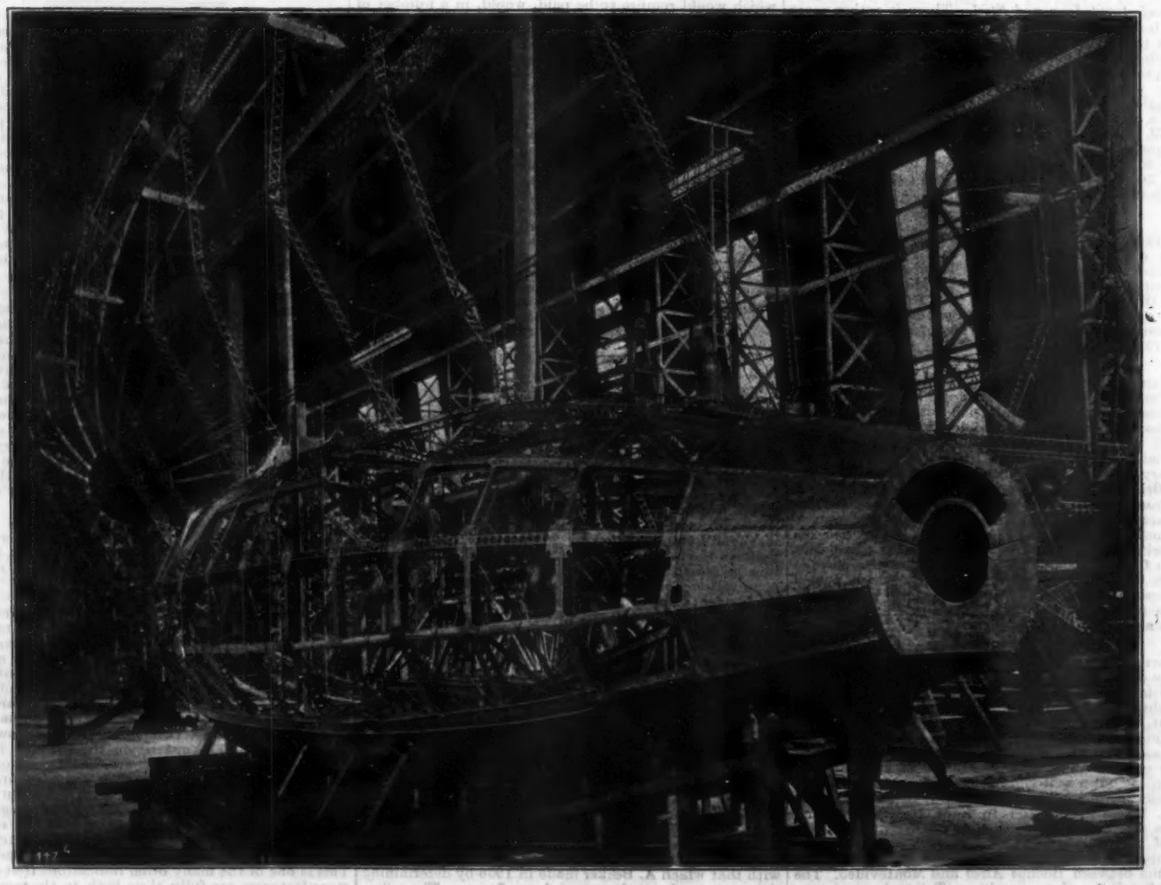


FIG. 27. FRAMEWORK OF WING MACHINERY CAR.

H.M. RIGID AIRSHIP "R. 80."

CONSTRUCTED BY MESSRS. VICKERS LIMITED, BARROW-IN-FURNESS.

(*For Description, see Page* 142.)

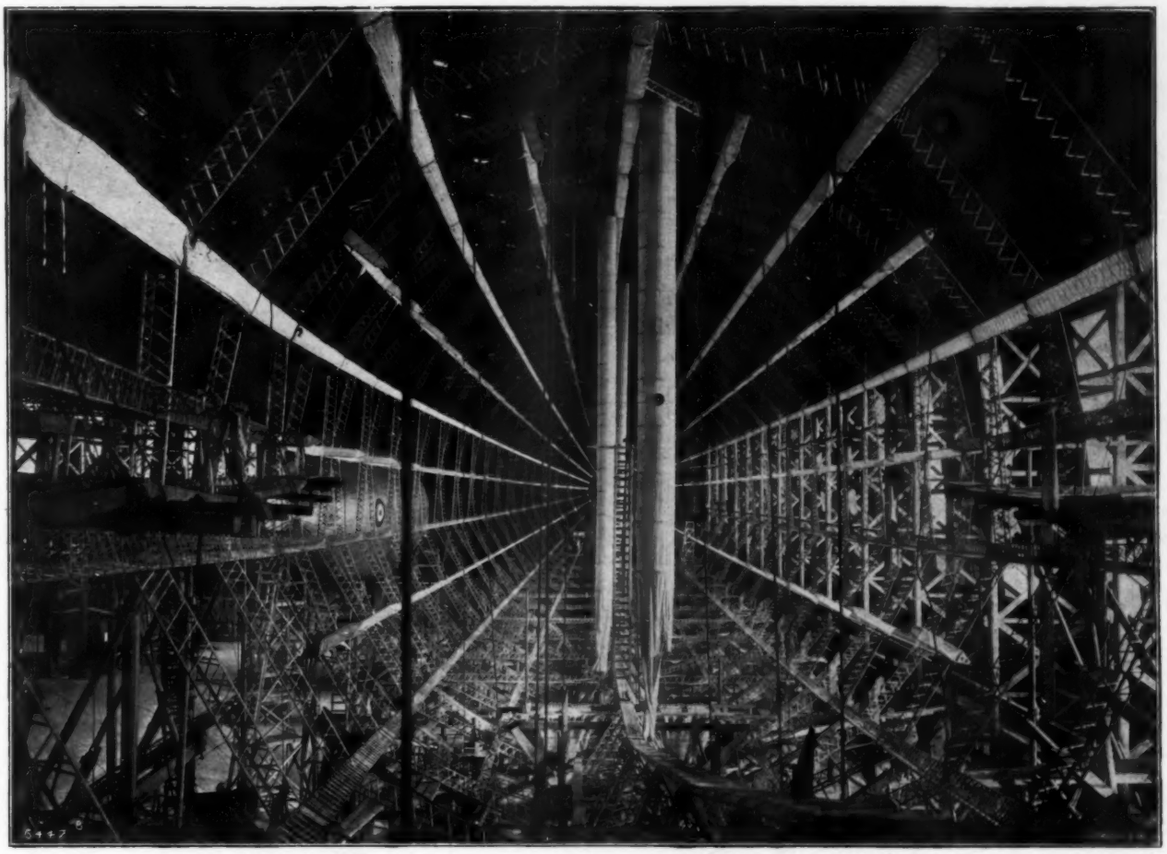


FIG. 18. INTERIOR OF HULL FRAMEWORK SHOWING VENT TRUNKS AND CORRIDOR.

FIG. 19. FRAMEWORK OF WING CAR SHOWING RADIATOR SLIDES AND ENGINE BEARERS.

(*To face page* 142.)

H.M. RIGID AIRSHIP "R. 80."

CONSTRUCTED BY MESSRS. VICKERS LIMITED, BARROW-IN-FURNESS.

(*For Description, see Page* 142.)

Fig. 1. SIDE ELEVATION OF SHIP.

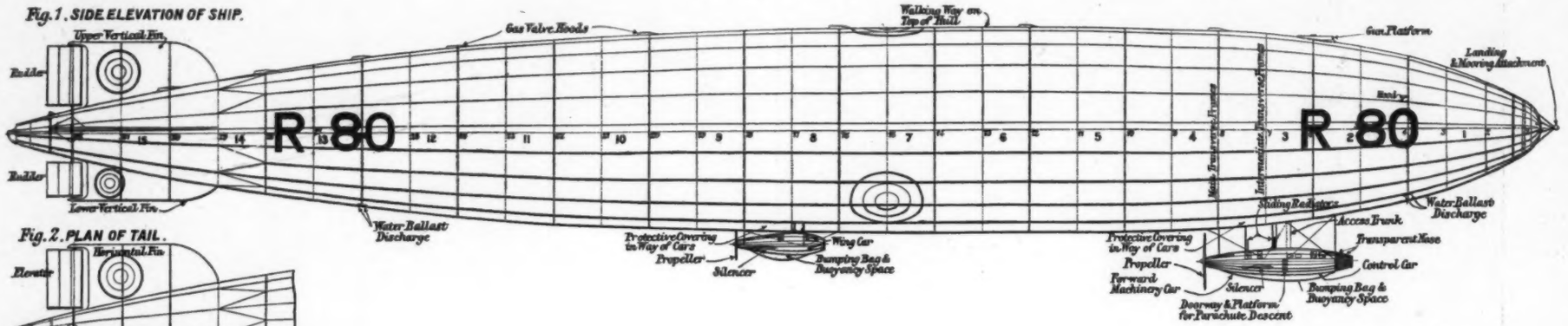


Fig. 2. PLAN OF TAIL.

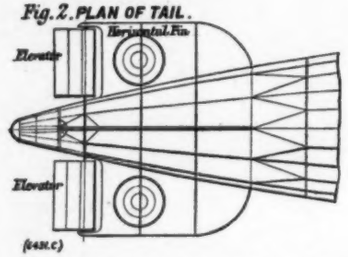


Fig. 3. LONGITUDINAL SECTION. GAS BAGS N°1 TO 15.

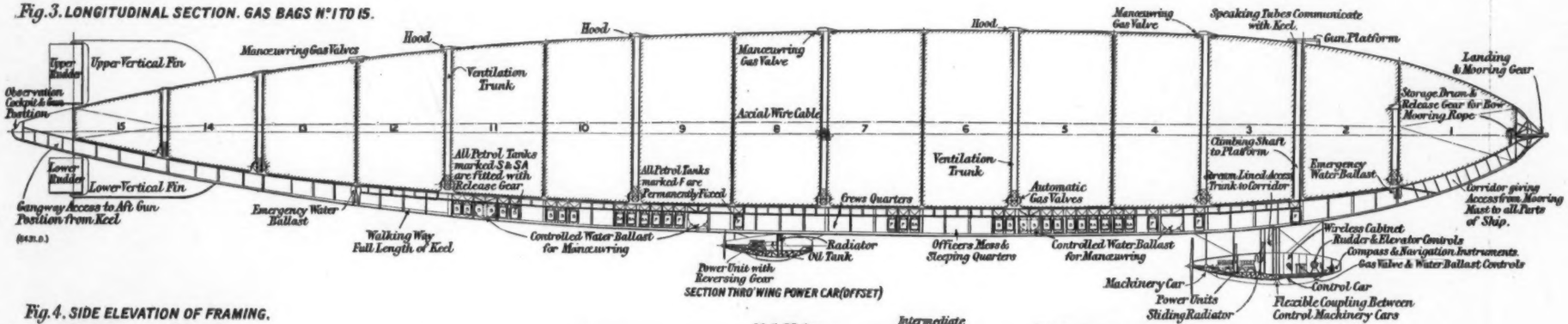

Upper Rudder
Upper Vertical Fin
Observation Cockpit & Gun Position
Lower Rudder
Lower Vertical Fin
Gangway Access to Aft Gun Position from Keel
(643 D.)
Manœuvring Gas Valves
Hood
Hood
Hood
Ventilation Trunk
Manœuvring Gas Valve
Axial Wire Cable
Manœuvring Gas Valve
Speaking Tubes Communicate with Keel.
Gun Platform
Landing & Mooring Gear
Storage Drum & Release Gear for Bow Mooring Rope
Climbing Shaft to Platform
Emergency Water Ballast
Screen Lined Access Trunk to Corridor
Corridor giving Access from Mooring Mast to all Parts of Ship.
All Petrol Tanks marked S & SA are Fitted with Release Gear
All Petrol Tanks marked P are Permanently Fixed
Ventilation Trunk
Automatic Gas Valves
Emergency Water Ballast
Walking Way Full Length of Keel
Controlled Water Ballast for Manœuvring
Crews Quarters
Radiator
Oil Tank
Power Unit with Reversing Gear
SECTION THRO' WING POWER CAR (OFFSET)
Officers Mess & Sleeping Quarters
Controlled Water Ballast for Manœuvring
Wireless Cabinet
Rudder & Elevator Controls
Compass & Navigation Instruments
Gas Valve & Water Ballast Controls
Machinery Car
Power Units Sliding Radiator
Control Car
Flexible Coupling Between Control Machinery Cars

Fig. 4. SIDE ELEVATION OF FRAMING.

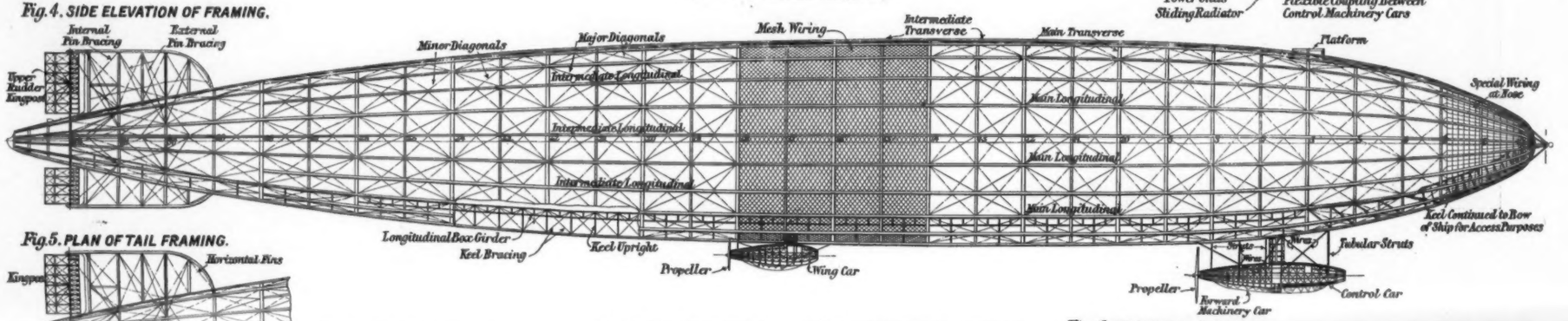


Fig. 5. PLAN OF TAIL FRAMING.

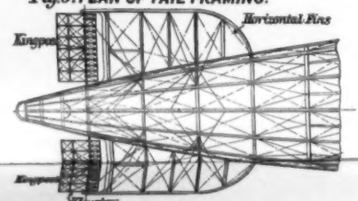


Fig. 6. END VIEW OF SHIP LOOKING FORWARD.

Fig. 7. END VIEW OF SHIP LOOKING AFT.

Fig. 8. TRANSVERSE SECTION THRO' GAS BAG.

Fig. 9. TRANSVERSE SECTION AT INTERMEDIATE FRAME.

Fig. 10. TRANSVERSE SECTION AT MAIN FRAME.

Fig.6. END VIEW OF SHIP LOOKING FORWARD.

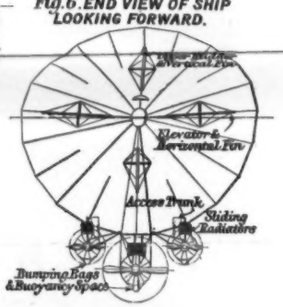


Fig.7. END VIEW OF SHIP LOOKING AFT.

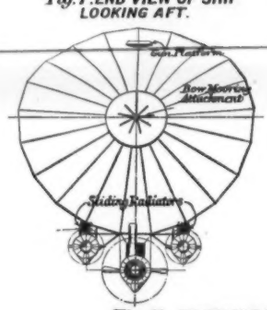
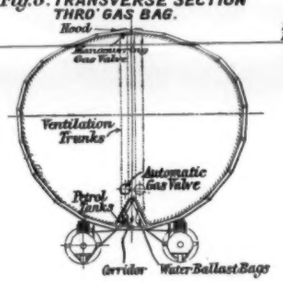


Fig.8. TRANSVERSE SECTION THRO' GAS BAG.



AT INTERMEDIATE FRAME.

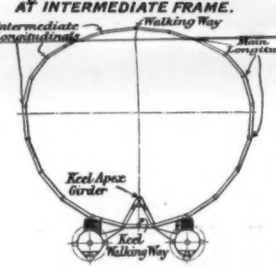


Fig.10. TRANSVERSE SECTION AT MAIN FRAME.

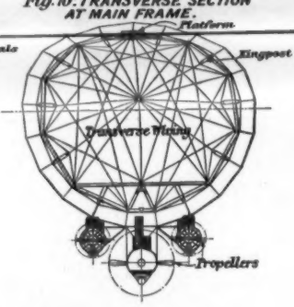


Fig.11. FORWARD MACHINERY AND CONTROL CAR.

LONGITUDINAL ELEVATION WITH OUTER STARBOARD SIDE CASING REMOVED.

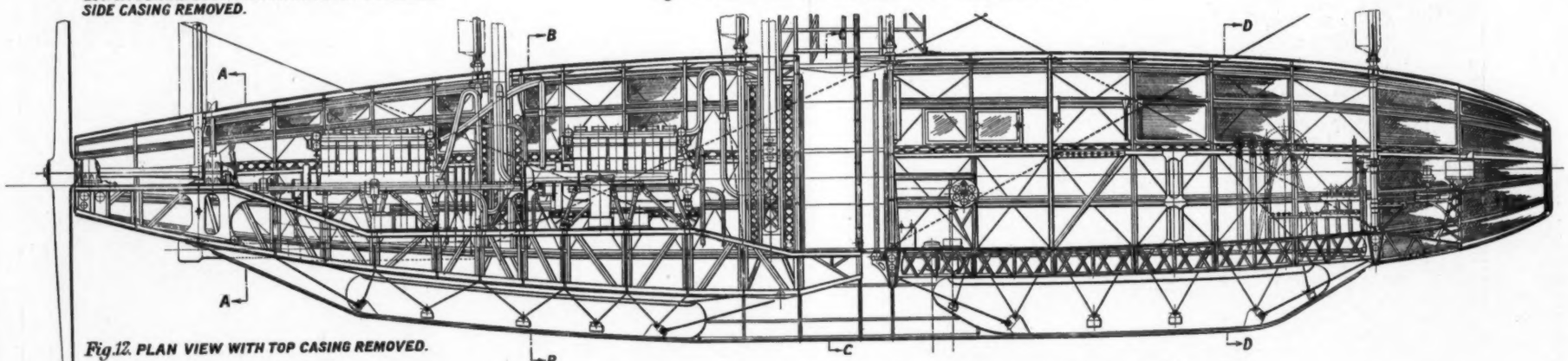


Fig.12. PLAN VIEW WITH TOP CASING REMOVED.

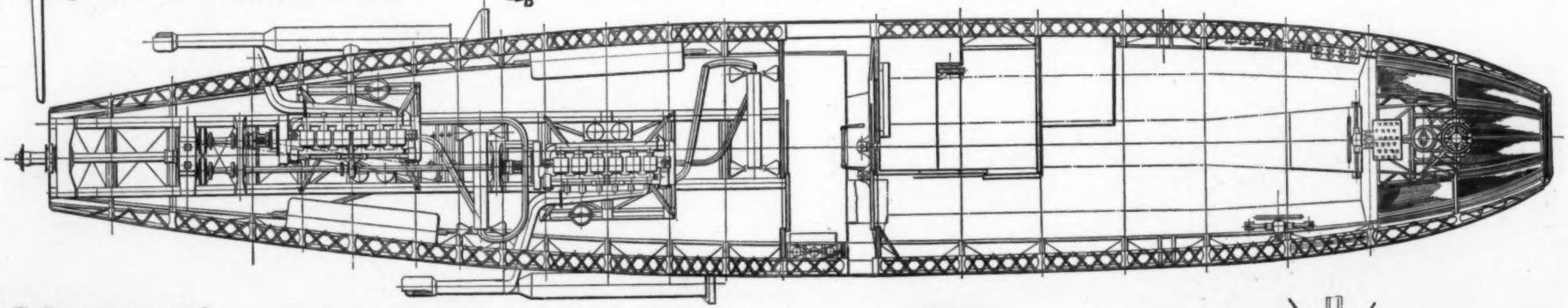


Fig.13. SECTION ON LINE A.A.

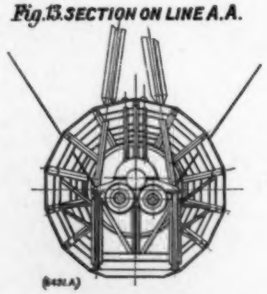


Fig.14. SECTION ON LINE B.B.

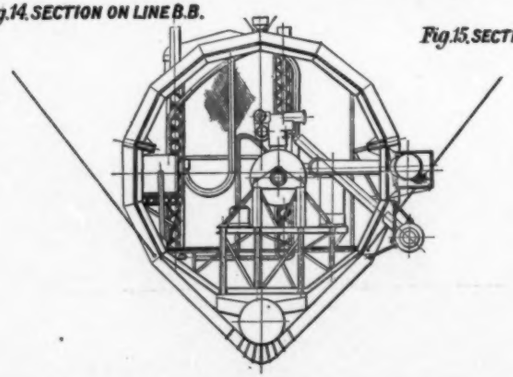


Fig.15. SECTION ON LINE C.C.

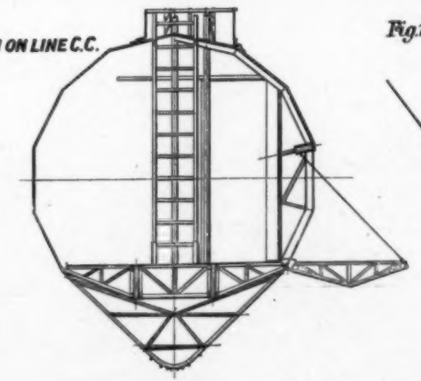
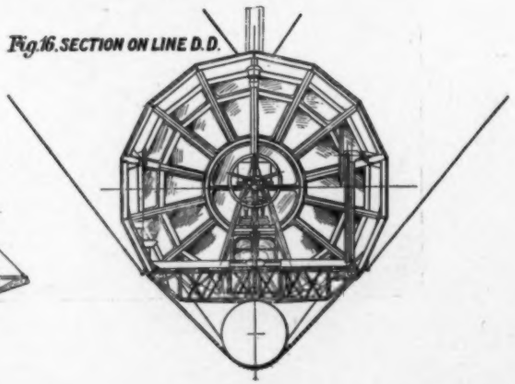


Fig.16. SECTION ON LINE D.D.



H.M. RIGID AIRSHIP "R. 80."

CONSTRUCTED BY MESSRS. VICKERS LIMITED, BARROW-IN-FURNESS.

(*For Description, see Page* 142.)

FIG. 20. AIRSHIP BEING INFLATED; GASBAGS HALF FILLED.

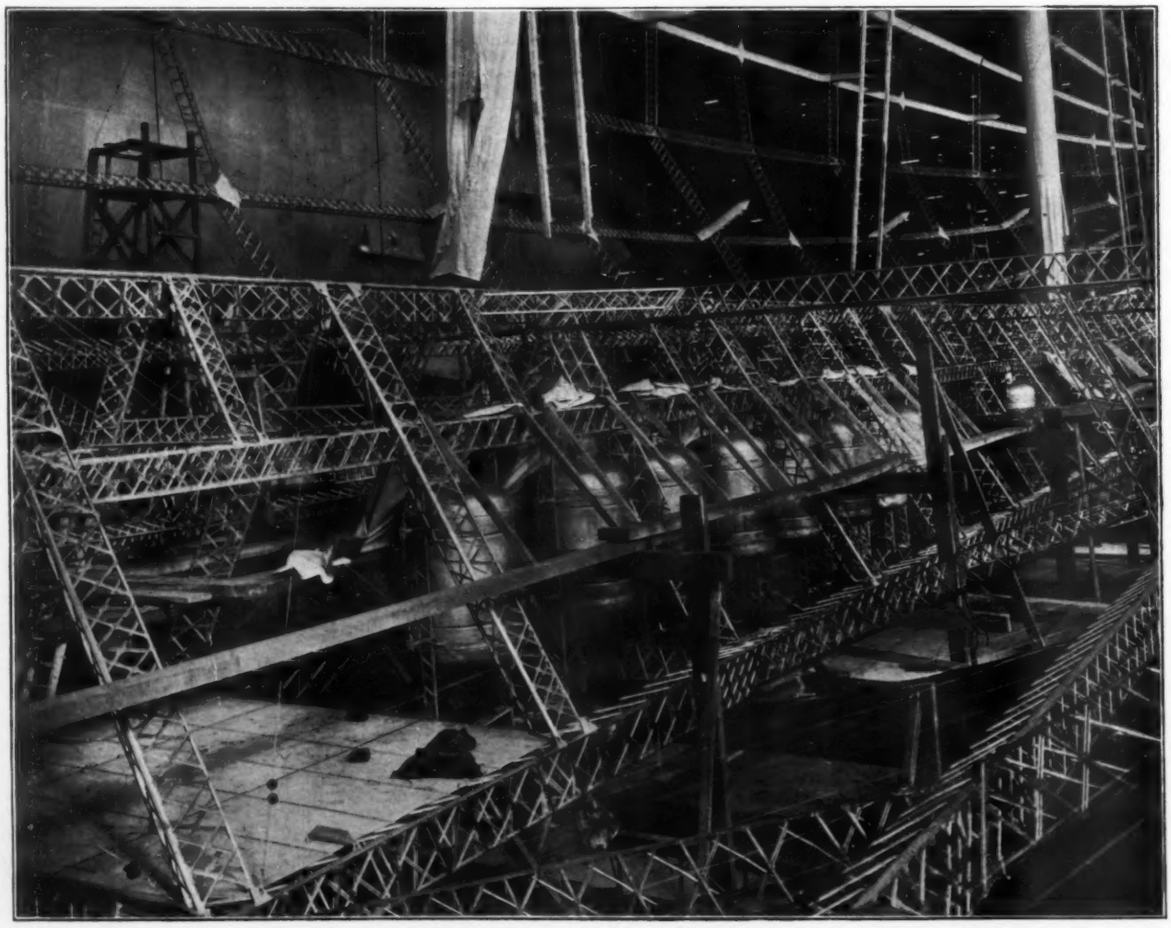


FIG. 21. FRAMEWORK OF CORRIDOR SHOWING PETROL TANKS.

(*To face page* 143)

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TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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With One Two-Page Plate and Two One-Page Plates of H.M. RIGID AIRSHIP "R. 80."

NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s. 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. So long as postal rates remain as at present there will be no increase in the price of copies sent by inland post, which will continue at 1s. 2d. post free.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers; therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

ENGINEERING.

FRIDAY, JULY 30, 1920.

MARINE REQUIREMENTS.

How often the phrase "suitable to, or in keeping with, marine requirements" meets the eye! There can also be related numerous examples of types of machines applied to some duty in connection with the propulsion of ships, which, in spite of a very considerable record of successful performance with land installations, did not give the requisite satisfaction at sea and were rejected as unsuitable. The marine market is a large one, and is continuously being assailed by those responsible for the development of mechanical novelties designed to give increased economy of fuel, with perhaps, in addition, an augmentation of the cargo-carrying capacity of the ship or some other important advantages. It would, therefore, be of considerable interest if these conditions could be stated, analysed and reduced to simple terms in the light of which any proposal for marine work could be critically examined. Such synthesis would also serve to guide enthusiastic pioneers anxious to capture a share of the marine work, who often themselves have little actual experience of sea-going conditions and by rushing in where others fear to tread, do harm by retarding the progress and application of an innovation possibly having many potentialities. Merit in the long run will undoubtedly win through, but the process of application will certainly be expedited by a careful survey of the particular and unique conditions which must rigidly be met. Naturally, these cannot be specified in an absolute sense. For instance, degree of reliability is a relative quality. It is obvious that for marine work the utmost security in this direction must be attained, and the risks which can be taken whatever the prospective gain, are only a small percentage of those possible with shore plants. The complete stoppage of a land plant at the very worst, rarely causes other than temporary inconvenience and slight pecuniary loss. Quite generally spare machines or alternative methods of obtaining power are available to fill the gap. In any case, the best technical guidance and assistance and unlimited resources can almost immediately be applied to effect a speedy repair. The number and extent of spares kept on the spot is only limited by the question of first cost, but in any case despatch by rail and often by passenger train is available.

The marine case involves other considerations. Firstly, the spares carried are equally limited by considerations of cost. It is further useless to carry spares that cannot readily be shipped into place by the only lifting and handling gear available, generally chain blocks and tackle. No external assistance can be relied upon in the event of a breakdown at sea, the ship's engineers must draw entirely upon their own resources without the assistance of plant other than at best one or two small machine tools, an anvil, and the like. This, however, is not the most important issue. Not only is the safety of the whole ship involved, but life may be endangered by a complete breakdown. The financial loss consequent upon a breakdown at sea is not measured as is quite often the case on land, by the difference in cost between the power generated by the machine which has broken down, and that used to take its place plus the sum of the expenses of the actual replacements, but is represented by the loss of earning capacity, together with the dock dues, etc., plus the cost of replacements often under conditions making for high charges under this heading. Salvage dues, as is well known, are heavy, and many examples of splendid and ingenious performance by marine engineers with a view to their avoidance could be given. Before detailing certain of the more important considerations making for the utmost degree of reliability, some of the other factors which must be taken into account may be stated. Reliability of running continuously is not of greater importance than a complete readiness of the machinery to respond without fail to the demands of manœuvring of the ship in respect of starting, stopping and reversing. Economy of fuel, lightness and capacity for absorbing small space are most valuable assets for marine work, but these advantages are very quickly negatived if reliability is in any way sacrificed.

Marine machinery does not operate on a solid platform. A ship is a flexible structure, and so the question of rigidity of bedplates and alignment of shafts must be viewed from this standpoint. The rolling or pitching of a ship in a heavy seaway makes relatively difficult the lightest duty, so that those parts requiring regular attention should be readily accessible, in view especially of the fact that the average engine-room is sometimes not too well illuminated. Those parts requiring dismantling for examination, or refit, from time to time, should be easily accessible and designed for ready handling with the appliances available. In every case where periodic inspection might give warning of impending trouble, that attention must be facilitated to the utmost. The scantlings of the design must take account of the stresses imposed by the uneven running of an engine with the ship in a heavy seaway, and the impossibility of ensuring always for that degree of dryness and cleanliness possible in land stations should be legislated for. Where spare gear is carried, it must be possible to ship any part into place with the least delay, since time is often a more vital factor afloat than ashore, as when a ship is stopped off a lee shore. A marine engine is neither a constant speed nor a constant load machine. Its speed varies with many conditions—the loading of the ship, the weather, whether in a sea way or in smooth water, against head, beam or following winds, and again, when towing another vessel. All these factors influence the ratio of power and speed of revolution and call for a high factor of safety, the utmost accessibility and handiness.

This subject of marine requirements has only been treated very briefly, but sufficient has been said to show why, for instance, the relatively uneconomical reciprocating steam engine for so long has held, and continues to hold, the marine field. It fulfils all the particular conditions of marine requirements to a degree not yet surpassed by any other prime mover, and when challenging its position, success will be more certain the greater the attention that is paid to the essential features, a number of which have been enumerated.

Surprise has often been expressed that the water-tube boiler makes such slow headway in the mercantile marine. The old cylindrical Scotch type remains the standard. The large quantity of water under pressure and in circulation, and the relatively large volume of steam contained in the steam space with this standard type gives virtues in security of operation under all conditions at sea, and enables, when manœuvring, for instance, the fluctuating demands in regard to power and speed of engine, to be immediately met. Again the record of satisfactory performance with the Scotch cylindrical steam generator is an argument of the utmost potency where marine engineers are concerned. Many schemes to overcome the prejudice towards water-tube boilers have been propounded, and for certain duties, where their quick steam raising properties, light weight and small space occupied are important considerations, they will be increasingly applied in the future. Only those types of water-tube generators specially designed

for marine work, however, can hope to succeed in the final issue. No less important than the main steam engines and the boilers, are the many auxiliaries upon which they depend, and it is perhaps in this field particularly that innovations are constantly being put upon the market. The immediate success of certain recent devices and accessories goes to prove the willingness of the marine superintendent engineer of to-day, to try out novelties, provided it can be proved and represented that they fulfil the essential tenets of marine requirements.

TRADE UNION RIVALRY.

THE judgment of the Court of Appeal in the Trade Union case, White *v.* Riley and Wood, appears to settle the difference of opinion between certain of the Judges of the High Court in this class of case. Mr. Justice Astbury's judgment, which was the subject of the appeal, was discussed in these columns recently, and it may be remembered that the action arose out of rivalry between the Workers' Union and the Curriers' Society. The parties were all employed by the Leamore Currying Company, the plaintiff being a member of the Workers' Union, and the defendants being members of the Curriers' Society. The defendants desired the plaintiff to join the Curriers' Society, but he would not agree to leave the Workers' Union, and following upon a shop meeting a letter signed by the defendant Ridley was sent to the employers intimating that the men would strike on a date mentioned unless the plaintiff joined the Curriers' Society or left the company's employment. In order to avoid a strike the company dismissed the plaintiff.

Mr. Justice Astbury held that the defendants had conspired by threats to injure the plaintiff by obtaining his dismissal from his employment because he would not leave his own Union and join the Curriers' Society, and that acting in combination they had induced and intentionally obtained a breach by the employers of the plaintiff's agreement of service; and he granted an injunction against the defendants to restrain from interfering with the plaintiff's employment and his right to dispose of his labour as he willed, and found the defendants liable to the plaintiff in 75*l.* damages. He held also that the defendants were not protected by the Trade Disputes Act, 1906, because, in his view, there was no dispute between employers and workmen or between workmen and workmen connected with the employment or non-employment or the terms of the employment or with the conditions of employment of any person, the real dispute being as to whether the plaintiff should join the Curriers' Society. In his judgment, as we pointed out, Mr. Justice Astbury appeared to differ from Mr. Justice Peterson's views as expressed in the Electrical Trades Union's case, Hodges *v.* Webb, and the judgment has now been reversed by the Court of Appeal.

The Court appears to have come to the conclusion that it was not clear that in dismissing the plaintiff without notice the employers were in breach of his contract, that is to say, it was not clear that he was entitled to notice; and, on the question whether there was any evidence to justify the finding that there had been a wrongful conspiracy to threaten and intimidate the employers, the Master of the Rolls said that there was no act amounting to a threat, apart from the letter and the refusal to withdraw it, nor was there any conduct by the defendants from which any threat or intimidation could be inferred. The mere statement of a number of workmen that they would not work with another workman was not by itself actionable. Men had a right to refuse to work with a man and to tell the employer what they proposed to do; and he could find nothing more in the case than the statement made to the employers that if the plaintiff did not join the Curriers' Society the men would not work with him. This, he thought, was not by itself actionable.

On the question whether the Trade Disputes Act applied to the case, the Master of the Rolls said that whether there was a trade dispute here was a question of fact, and no general rule could be laid down which could be used as a guide in every case of the kind, but his Lordship thought that there was such a dispute in the present case between workmen and workmen in the shop because of the restriction put upon the plaintiff's employment by the Curriers' Society.

The reversal of Mr. Justice Astbury's judgment is to be regretted from the point of view of employers and of individual workers, because in cases of this kind it would have operated to protect employers from having to choose between dismissing a worker whom they had no wish to dismiss or facing a strike, and it would have helped to protect workers from being forced to join a Trade Union against their will; but the protection which it would have afforded has now been withdrawn by the Court of Appeal's judgment. It remains to be seen whether the case will be carried to the House of Lords.

THE WORLD'S MERCHANT SHIPPING.

ALTHOUGH the figure is perhaps of little or no practical value, it is nevertheless interesting to know that, as a result of the action of enemy submarines and the diversion of resources normally employed in replacing losses and constructing new tonnage, the net reduction in the merchant shipping of the world during the last six years amounts to 3,516,000 tons. This, at all events, is the figure given as a result of a carefully considered estimate in the new edition of Lloyd's Register Book recently issued, and it refers only to sea-going steel steamers of over 100 gross tons. The figure has been arrived at on the assumption that the ratio of increase during the last six years would have been four-fifths of the average ratio of increase during the previous six years, and, on this assumption, the aggregate tonnage of steel steamers owned in the United Kingdom to-day would have been 21,420,000 but for the intervention of the war. The tonnage actually in British hands at the present time amounts to 18,111,000, but some further assumptions as to the future allocation of the ex-German tonnage brings the figure to 18,500,000 tons. The net British loss is thus 2,920,000 tons, while the German loss is more than twice as great, the figure for that country being 6,103,000 tons. In other countries the probable loss is estimated at 3,330,000 tons, but the United States fleet of steel sea-going steamers is now probably greater by 8,837,000 tons than it would have been in normal circumstances. The difference between the latter figure and the sum of the three losses previously mentioned gives the figure 3,516,000 tons as the probable net loss of shipping of the class considered for the whole world.

Coming now to actual figures, we can compare the positions of the principal maritime countries of the world at the end of June last with their positions six years ago from the valuable statistical tables published with the Register Book. In doing so we are, for simplicity, neglecting sailing vessels, which now make under 6 per cent. of the whole world's tonnage, and considering steamers and motor vessels of all kinds of 100 gross tons and upwards; figures in all cases will be given to the nearest 1,000 tons. The United Kingdom still owns the largest merchant fleet in the world, but the present British tonnage (18,111,000 as previously mentioned) is 781,000 tons less than the corresponding figure for 1914, which was 18,892,000 tons. Thus, in spite of increased construction and the large tonnage of ex-enemy vessels provisionally allocated to British management, the steam tonnage of the United Kingdom is now more than 4 per cent. less than it was immediately before the war, though our need for shipping has greatly increased in the interval. Most other countries, excluding Germany and Austria, have increased their merchant fleets, more or less, during the period we are considering, and some countries have materially improved their relative positions among the maritime nations of the world. The most notable improvement has, of course, occurred in the case of the United States, the sea-going merchant tonnage of that country having grown from 2,027,000 tons in 1914 to 12,406,000 tons at the present time. The American tonnage on the Great Lakes has, however, declined slightly from 2,260,000 to 2,119,000. Excluding vessels trading on the Great Lakes the United States now owns some 24 per cent. of the world's steam tonnage as compared with 4·7 per cent. in 1914, while the corresponding figures for the United Kingdom are 43·9 per cent. in 1914 and 35·1 per cent. in 1920. Japan is another country whose merchant fleet has been greatly added to, so that she now takes third place among shipping nations, as compared with sixth place before the war. In 1914 Japan owned 1,708,000 tons of steam shipping, while she now owns 2,996,000 tons, the difference of 1,288,000 tons representing an increase of more than 75 per cent. Large increases have also occurred in the merchant fleets of France and Italy, to which countries, as well as to the United Kingdom, a considerable amount of ex-enemy tonnage has been provisionally allotted. The increase in the case of France is 1,041,000 tons, the figures for 1914 and 1920 being 1,922,000 tons and 2,963,000 tons, respectively, while the Italian steamship tonnage has increased from 1,430,000 to 2,118,000, in the same period, *i.e.*, by 688,000 tons.

Collectively, the British Dominions now occupy a fairly important position among the maritime nations, owning between them 2,032,000 tons of steamships. This tonnage, which has increased by 400,000 tons during the last six years, gives them the sixth place in order of magnitude of tonnage owned, as compared with seventh place immediately before the war. Of the Scandinavian nations, Norway is the only one whose merchant fleet has been augmented during the period under consideration. The increase in this case is inconsiderable, amounting to only 23,000 tons, the figures for 1914 and 1920 being 1,957,000 tons and 1,980,000 tons, respectively. The other Scandinavian nations have not yet made good their losses, Sweden now owning 19,000 tons less than in 1914, and Denmark 51,000 tons less. The steam-tonnage of Sweden now totals 996,000, as compared with 1,015,000 in 1914, while the corresponding figures for Denmark are 719,000 and 770,000. Holland, on the other hand, has increased her steam tonnage from 1,472,000 to 1,773,000, *i.e.*, by 301,000 tons, but her relative position as a shipowning nation is unaltered. The Spanish merchant fleet has also grown, by 53,000 tons, from 884,000 tons in 1914 to 937,000 tons at the present time, while that of Greece seems to have suffered a greater proportional reduction than that of any other nation excepting enemy countries. The steam tonnage now owned in Greece amounts to but little more than 60 per cent. of that owned in 1914, at which time the aggregate tonnage of the Greek merchant fleet was 821,000. It is now only 497,000 tons, the reduction thus being 324,000 tons. As a result of the failure of its misguided efforts to dominate the world, the German nation to-day takes the thirteenth place among maritime countries instead of the second place she occupied in 1914, and might very well have been content with. Immediately before the war the steam tonnage of the German merchant fleet amounted to 5,135,000, of which only 419,000 tons are now recorded in the Register as German, the remainder having been captured, requisitioned or allocated to the Allies in accordance with the terms of the Peace Treaty. Austria and Hungary, which now exist as separate states, owned 1,052,000 tons of steamships before the war, but have now ceased entirely to be maritime countries, no ships being owned at the present time by either State.

The steam tonnage for the whole world shows an increase of 8,501,000 tons since the outbreak of war, at which time the aggregate tonnage amounted to 45,404,000. The present world's tonnage is 53,905,000, but it should be mentioned that, excepting the case of the United States, the increases which have occurred, and have been referred to above, have been made for the most part during the last twelve months; in that period the merchant fleets of the world have been augmented to the extent of over 6,000,000 tons. The actual number of steamers included in the world's merchant fleet to-day is 26,513, of which 9,779 fly the British flag; of this number, however, 1,666 are owned in the Dominions. The United States, including the Philippine Islands, owns 4,110 steamers, of which 466 trade on the Great Lakes. The Japanese merchant fleet numbers 1,940 steamers, and the

other countries owning more than 1,000 steamers, are Norway with 1,596, France with 1,400, and Sweden with 1,072.

It may be interesting to add, in conclusion, that of 16,836 steamers registered by the different classification societies of the world, considerably more than half, 9,332 to be exact, are classed by Lloyd's Register. The British Corporation accounts for a further 1,007 steamers, while, of foreign organisations, the Bureau Veritas has classed the largest number of steamers, the figure for that body to-day being 3,386. So far the American Bureau of Shipping has classed only 1467 steamers, of which 280 are included in the Great Lakes Register. Next in order of importance comes the Norske Veritas, which has classed 963 steamers, and this society is followed by the Registro Navale Italiano and the Adriatico Veritas which have classed, respectively, 396 and 279 steamers. Some steamers are, in all probability, included in more than one register, but it is satisfactory to notice that, of the total number of classifications made, considerably over 60 per cent. have been effected with British concerns.

PERCOLATION WELLS IN INDIA.

In the theoretical treatment of the flow of water into a percolation well as found in text books, the following conditions are assumed, viz., that the well is sunk down to impermeable soil, that the flow into the well is radial, and that the entry of water into the well is free, that is the flow into the well encounters no resistance. Such conditions only obtain where wells are sunk into stable water bearing soils which require no steining or lining to support the sides of the well. This is not usually the case met with in India, where percolation wells are sunk in recent alluvial deposits, viz., those beds of shingle, sand, loam or clay which have not yet been consolidated into rock, and a steining or lining of some sort is necessary. The steining generally consists of a cylinder of masonry sunk into the soil, which in the case of wells for a public water supply must be impermeable in order to prevent pollution. Wells for irrigation sometimes have weep holes in the steining, or the lower portion of the steining is built with rings of dry set brick or stone. The water bearing soil being usually of considerably greater depth than the well, the bulk of the supply rises vertically up through the soil in the bottom of the well. That is, the flow into the well is not radial.

In the majority of cases where an ample supply is required the wells are sunk to beds of sand, or sandy soils; and the amount of water such a well can give, depends on the area of sand exposed at the bottom of the well, that is on the internal diameter of the steining, and the critical discharge per square feet area of the sand which depends on the coarseness, and specific gravity of the sand. The critical discharge per square foot area of the sand is that produced by a pumping head which causes a velocity sufficient just not to move or "blow" sand into the well. This head is called the critical head; if this head is increased sand is blown into the well, and if the same quantity of water is being pumped from the well, sand will continue to be blown into the well until the well is filled with sand to such a depth that no greater supply can be taken from the well than the critical discharge. If in order to obtain a greater supply the sand is dredged out of the well, and the overtaxing continues, the well will again be filled with sand; and in time if the above process is continued a large cavity will form in the sub-soil and either the earth round the well will collapse, or the masonry cylinder will sink bodily. Therefore from a percolation well sunk in sandy soil it is impossible to obtain more than a certain definite discharge, whatever the depth to which the steining is sunk, and any attempt to get more than this discharge will endanger the stability of the well. Various devices have been tried to overcome the sand blows, sometimes a depth of 3 ft. to 4 ft. of broken stone is placed at the bottom of a well to weigh down the sand; but this has only given temporary relief as the sand in a short time is drawn up through the interstices of the stone and the "plug," as it is called, soon gets choked. As will be shown later the maximum velocity of entry vertically upwards through the bottom of the well is at the inside rim of the steining. Native well sinkers from long experience are aware of this fact, and sink a cylinder of grass rolls inside the steining till the bottom of it is about a foot below the well curb; the annular space between the outside of the grass cylinder and the inside face of the steining is filled with broken stone and shingle; the surface of the sand is exposed in the centre of the well. Sometimes a roll of grass about 9 in. in thickness is tucked under the well curb, the sand scooped out inside the steining for a depth of 1 ft. or 2 ft. to the level of the grass roll and filled with broken stone. If the sand is fine none of the above plans meet with success. Mr. Farrant, sometime chief engineer Punjaub P.W.D., fixes the critical head for Punjaub sands at from 4 ft. to 6 ft. At the Trichinopoly water works pumping station, South India, the fine sand of the Cauvery River is drawn into the pumps when the pumping head exceeds 5 ft. In the case of the coarser and heavier quartz sands of South Indian rivers the critical head exceeds 6 ft. The difficulty of sand blows in wells at the watering stations on Indian railways is overcome by constructing the wells of large diameter, so as to reduce the velocity of entry and obtain storage.

In order to obtain the specific yield of the soil into which it is proposed to sink wells for a public water supply, or for irrigation, a test well is sunk to the full depth it is proposed to sink the permanent wells, and the specific yield is obtained as shown below. It is assumed in the following calculations that the steining is an impermeable cylinder of masonry.

If A be the cross sectional area of the well in square feet.

P the rate of pumping in cubic feet per hour.

h the depth the water in the well is reduced, or the head in feet after t hours pumping.

$P\,dt = A\,dh +$ the spring flow into the well.

If K be the specific yield of the well in cubic feet per hour under a head of 1 ft., the spring flow into the well under a head of h'

$$= K h$$

$$\therefore \quad P\,dt = A\,dh + K h\,dt.$$

If H = the head or reduction of water in the well when the rate of pumping equals the spring flow and the water level remains steady while constant pumping is in progress for a considerable period of time

$$P = K H$$

from which equation K can be ascertained, and $\frac{K}{A}$ will be the specific yield of the soil per square foot area of a well under a head of 1 ft.

$$t = \frac{A}{K} \log_e \frac{H}{H - h}$$

Knowing $\frac{K}{A}$ for the soil and H the head at which the rate of inflow equals the rate of pumping, the time taken to reduce the water in the well to any depth h can be obtained.

Great care must be taken, particularly in the case of the investigation of a town water supply, that the period of pumping in the test well is carried out for a sufficient length of time in order to observe the constancy of the water level during that period. The diminution of ground water level is so slow, that years often elapse before there is evidence of a definite lowering of the ground water level. Also it is rarely that a continuous discharge of any magnitude can be obtained from a percolation well at a moderate head, except in the case of wells sunk in the water bearing beds of Indian rivers, or sand beds adjacent to and periodically fed by them, or in large sandy deposits into which streams flow, or which receive heavy rainfall. Generally the flow from the tributary area of a well is so slow that a moderately powerful pump soon empties the well, or reduces the water level to the "critical depth," and a much longer time is taken for the water in the well to recoup or rise to its original level.

A more usual way of obtaining the values of $\frac{K}{A}$ for a water-bearing soil is by a recuperation test which is described below.

If H is the normal depth of water, or the "critical head," in the test well before any pumping is carried out; and the well is pumped down to H, and allowed to recoup, and if at the end of t hours the water has risen to a distance or depth h below the normal ground water level before pumping.

In a short time dt the water will rise dh, and if A is the cross sectional area of the well in square feet. The spring flow entering the well in any short time dt will $= -A\,dh$; the $-$ sign being used as h is decreasing. The spring flow entering the well $= Kh$

$$\therefore \quad K h\,dt = -A\,dh$$

$$t = -\frac{A}{K} \log_e h + C$$

$$C = \frac{A}{K} \log_e H$$

$$\therefore \quad t = \frac{A}{K} \log_e \frac{H}{h}$$

and

$$\frac{K}{A} = \frac{1}{t} \log_e \frac{H}{h}$$

By observing the values of h for various times t successive values of $\frac{K}{A}$ can be obtained. If the water-bearing soil is uniform for the depth of the well, the values of $\frac{K}{A}$ so obtained will be nearly equal, otherwise a mean value of $\frac{K}{A}$ must be taken. $\frac{K}{A}$ is called the "specific yield" of the soil per square foot sectional area of a well sunk in it, under a head of 1 ft. Mr. Farrant states that from observations made in Punjaub soils, in the case of wells steined with an impermeable cylinder of masonry $\frac{K}{A}$ varies from $\frac{1}{4}$ cub. ft. per hour to $\frac{1}{2}$ cub. ft. per hour for sandy and clayey soils. From observations made in the coarse sands of the Madras Presidency $\frac{K}{A}$ is about 1 cub. ft. per hour.

Turning now to the equation

$$P\,dt = A\,dh + K h\,dt$$

we can prove that

$$P = \frac{K h}{1 - e^{-\frac{K}{A} t}}$$

$\therefore$ if K is known for the well, and if in any time t the water in a well is reduced h feet in depth, the average rate of pumping during the period can be ascertained.

If T is the time the water in the well is reduced to H; or if H is the normal depth of water before pumping and the well is pumped dry in T hours

PT is the total quantity pumped out of the well.

$$\therefore \quad PT = \frac{K H}{1 - e^{-\frac{K}{A} T}} \times T$$

The spring yield during this period will be PT $-$ AH.

Again if t is the time the water rises in a well by recoupment from a depth H below normal ground water level to a depth h below the same level

$$t = \frac{A}{K} \log_e \frac{H}{h}$$

And if T is the total time of recoupment of the well to its original level before pumping

$$T \text{ will equal } \frac{A}{K} \log_e \frac{H}{O}$$

This will make T infinity. Experiment shows that when a well is pumped out, and allowed to recoup, the water, unless the soil is very porous, rarely rises to its original level, except after a considerable lapse of time, therefore by making h very small (the value varying with the nature of the soil), we can obtain a reasonably accurate value for T.

It may be also noted that

$$h = H e^{-\frac{K}{A} t}$$

The safe yield from a percolation well is the supply that can be drawn continuously from it without permanently lowering the ground water level, or eventually running the well dry. It is usual to make such tests at the time the ground water is at its lowest level. The well is pumped out dry, or down to the critical head the soil will stand, and allowed to recuperate; then if as stated above P is the rate of pumping and it takes T, hours to pump the well dry, or down to its critical head,

and it takes T_2 hours for the well to recuperate to nearly its original level, we get PT_1 as the total quantity pumped out of the well, and this is the safe yield that can be expected from the well in $T_1 + T_2$ hours. If it has not been possible to observe the rate of pumping, or the total time of recoupment, then if $\frac{K}{A}$ has been ascertained from observations on the rate of recoupment, the total quantity pumped is given by the formula

$$P T_1 = \frac{K H}{1 - e^{-\frac{K}{A} T_1}} \times T_1$$

And the time of recoupment is given by the formula

$$T_2 = \frac{A}{K} \log_e \frac{H}{h}$$

by making h as small as is considered suitable for the soil a reasonably accurate value of T_2 can be obtained. An example of a test made on a percolation well is given below.

The case of a well with a steining consisting of an impermeable cylinder of masonry sunk into homogeneous water bearing soil of considerable depth may also be treated as follows :—

If r is the radius of the well to the centre of the steining, and $2a$ the thickness of the steining, the flow into the well will take the lines of least resistance, and the lines of flow for all practical purposes may be represented by arcs of concentric circles, as shown in the diagram Fig. 1.

If h is the pumping or static head the velocity along any line of flow ab at a distance x from the centre of the steining c will be $\frac{M h}{\pi x}$, where M is the modulus or transmission constant of the soil, or the quantity of water that would be transmitted in a unit of time through a cylinder of the soil one unit in length, one unit cross sectional area, under one unit difference of pressure at the ends of, and just inside the cylinder. This M must not be confused with $\frac{K}{A}$. The velocity of flow, or entry, into the well along any path ab, Fig. 1, is

$$\frac{M h}{\pi x}$$

And this is a maximum at the inner rim of the steining. The flow along any tube ab

$$= \frac{M h}{\pi x} d x$$

The flow into any circle concentric to o is

$$\frac{M h}{\pi x} d x \times 2 \pi (r - x)$$

The total flow into the well will be

$$2 M h \left\{ r \log_e \frac{r}{a} - (r - a) \right\}$$

A yield test was made at the well in the glass factory, Madras, shown in Fig. 2 :—

Diameter of well, 8 ft.

Depth of well from ground level, 22 ft.

The steining is a cylinder of brick masonry in fairly good condition, the thickness was only 9 in., and it therefore cannot be considered absolutely watertight, but the supply percolating through the steining must be very small.

The bottom of the well showed moderately coarse sand.

The levels are reduced to heights above mean sea level. "Yield tests" were made by pumping out the water from the well and allowing it to recoup. The water level in the well could not be lowered below —3·41 as the steining showed signs of bulging. The discharge from the pump was gauged over a Rt < notch. The table annexed gives details of the pumping test.

The total discharge from the pump = 693 c.f.

Taking T as 1 hour, K = 50, and $\frac{K}{A} = 1$

$$P T = \frac{K H}{1 - e^{-\frac{K}{A} T}} \times T = 655 \text{ c.f.}$$

The difference being about 7 per cent.

The value of K in column 11 is obtained by taking a mean value of h during the intervals of 5 minutes hence as the differences between h for successive intervals grows less more accurate values of K are obtained.

K may for all practical purposes be taken as 50, and $\frac{K}{A}$ as 1, which is the "specific yield" for the class of sand met with.

The well was allowed to recoup and rose from —3·41 at 5.45 p.m. to —1·41 at 6-1½ p.m., making t = 16·5 minutes, or 0·275 hours. Further observations were stopped on account of rain and darkness.

Taking

$$K = \frac{A}{t} (\log_e H - \log_e h)$$

$A = 50{\cdot}25$ $\quad H = 8{\cdot}28$

$t = 0{\cdot}275$ $\quad h = 6{\cdot}28$

$K = 50{\cdot}25$ and $\frac{K}{A} = 1$

Estimating the time of recoupment to nearly its original level we may take h for such soil to be = 0·01.

$$T = \frac{A}{K} (\log_e H - \log_e h)$$

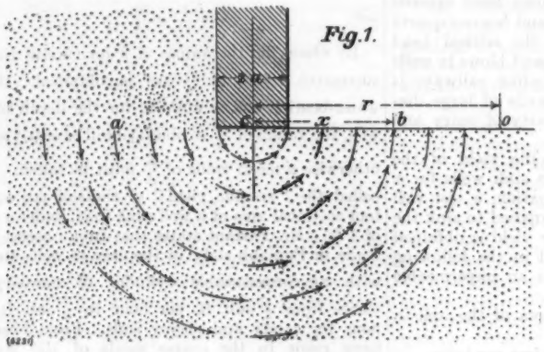
$$= 1 (\log_e 8{\cdot}28 - \log_e 0{\cdot}01) = 6{\cdot}7 \text{ hours}$$

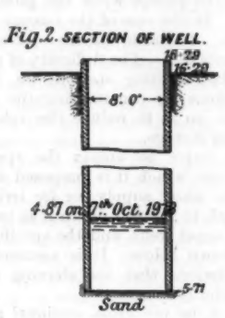
Total time of pumping, say, 1 hour.

∴ Safe yield may be taken as 693 cub. ft. in 7·7 hours, or

About 2,100 cub. ft. per day of 24 hours.

A test was made on September 21, 1918. The rest water level was 7·17 and the water in the well was lowered to —1·93 or 9·13 ft. in 1½ hours. The total quantity gauged was 1002·92 cub. ft. The time for total recoupment was stated to be 9 hours 17 minutes, the last three hours were in the dark, and there may have been some difficulty in observing the water level at that time. The total time pumping to first recoupment was therefore 10·5 hours; which works out at a safe yield of 2,280 cub. ft. in 24 hours. We may therefore reasonably expect a safe yield from the well of 2,100 cub. ft. to 2,200 cub. ft. in 24 hours, and we may assume that the specific yield or $\frac{K}{A}$ for similar wells sunk in the sandy area, to be 1 cub. ft. per hour per square foot sectional area of the well under a head of 1 ft.





WELL AT GLASS FACTORY, MADRAS.

Diameter, 8 ft.; cross-section area, 50·25 square feet; rest water level, 4·87; yield test on 7 October, 1918.

1	2	3	4	5	6	7	8	9	10	11
Time P.M.	Water Level in Well.	Interval in Minutes.	Difference of Water Level.	Mean Head in Feet.	Right < Notch Reading during Interval.	Quantity discharged from Pump during Interval.	Capacity of Well for Interval.	Spring Flow into Well during Interval.	Rate of Spring Flow.	Estimated Values of K.
h. m.	m.s.l.		ft.	ft.	in.	cub. ft.	cub. ft.		cub. ft. per hour.	
4 50	4·87		—	—	—	—	—	—	—	—
4 55	2·87		2	1	5½	107·47	100·5	6·95	83·4	—
5 0	1·46		1·41	2·7	5	84·86	71·00	13·86	166·00	61
5 5	0·36		1·10	3·96	4¾	74·42	55·28	19·14	230·00	58
5 10	−0·54		1·90	4·98	4¾	65·6	45·22	20·38	244·00	49
5 15	−1·33		0·79	5·80	4¾	65·6	39·60	25·91	311·00	54
5 20	−1·91	Five minutes.	0·58	6·49	4½	56·5	29·14	27·36	328·00	51
5 25	−2·37		0·46	7·01	4½	52·0	23·10	28·90	347·00	50
5 30	−2·77		0·40	7·44	4½	52·0	20·01	32·49	390·00	52
5 35	−3·08		0·31	7·79	4	48·8	15·5	33·3	400·00	52
5 40	−3·29		0·21	8·05	3¾	45·00	10·55	34·5	413·00	51
5 45	−3·41		0·12	8·22	3½	41·6	6·03	35·57	427·00	52

HELIUM, ITS PRODUCTION AND USES.

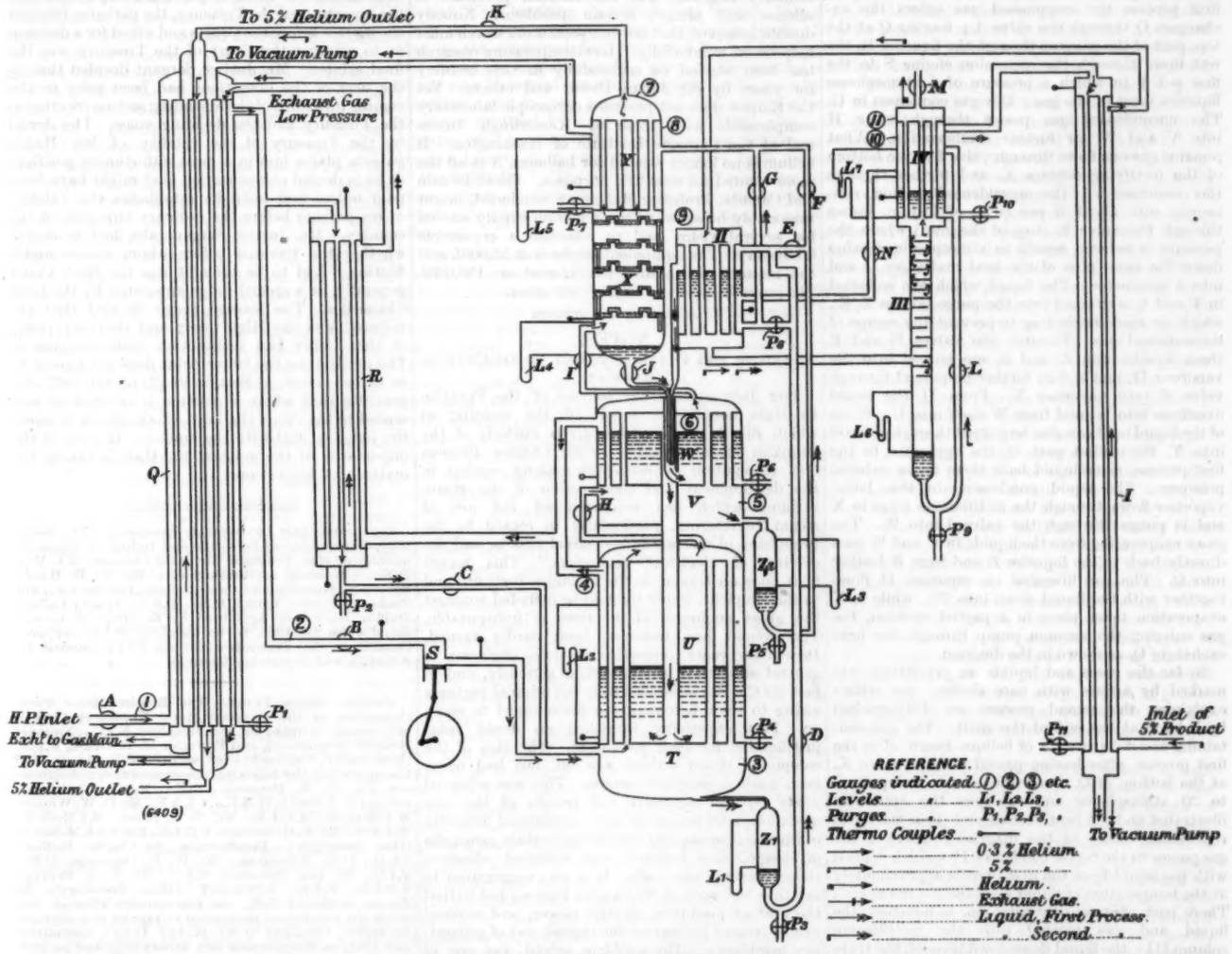
WHEN we commented upon the extraction of helium from natural gas in our issue of May 2, 1919, we mainly relied upon the information given by Dr. F. G. Cottrell on his being presented with the Perkin medal. We did not fail to point out that the research had originated in this country. But we were not in a position at that time to speak in more than general terms of the share taken by British and Canadian scientists in solving this problem. That share was explained by Professor J. C. McLennan, F.R.S., of Toronto, in a lecture on "Helium, its Production and Uses," which he delivered before the Chemical Society on June 18, and Sir Richard Threlfall, F.R.S., supporting the vote of thanks to the lecturer, supplemented the historical introduction. In October, 1914, it was rumoured that German airships were charged with an uninflammable gas. The gas, Sir Richard thought, could only be either ammonia—obviously out of the question for various reasons—or helium. Helium was known to escape from mines (studied in Germany) and to occur in springs (there were Moureu and Lepape's investigations of 1914 in France) and in natural gas, also in the remarkable outburst of gases at Neuengamme, near Hamburg. Calculating the helium probably available at Hamburg, Sir Richard concluded that it could not fill more than two balloons, and that the Germans would hardly lay down a helium plant under those conditions. But England might do, what Germany could not do. Sir Richard obtained samples of natural gas from Kansas, in which Sir William Ramsay found 1·5 per cent. of helium, this work on helium and its diffusion through fabrics being the last investigation he was able to carry out. Early in spring, 1915, Sir Richard then submitted an engineering scheme for helium extraction to the Admiralty, and with that his share in the work practically came to an end.

In the autumn of 1915, when the helium problem exercised scientists over here, as well as in America and Germany, Professor McLennan was invited by the Board of Invention and Research to undertake a survey of the helium-sources of Canada and of the Empire and to investigate their production. Before referring to this work, however, Professor McLennan briefly reviewed the history of helium. Discovered by Janssen in 1868, as an unknown element in the solar spectrum, for which Frank-

land and Lockyer in vain searched for on the Earth, Palmieri in 1882 observed the helium lines in the gases from the lava of Vesuvius, and Ramsay finally isolated it from the gas from cleveite, in 1895. Helium was then found to be widely diffused, yet so scarce that prior to 1918 hardly more than 4 cub. m. of helium were altogether isolated by the various workers, and the cost was 300*l.* per cubic foot. The experiments, which Sir E. Rutherford described in his Bakerian lecture before the Royal Society a few weeks ago, on the disintegration of the atoms of some other elements into helium enhance the romance of helium, which, when liquefied, brings us within 1 deg. or 2 deg. C. of absolute zero (Kamerlingh Onnes).

But we turn to the results of the survey.* In Ontario, Professor McLennan found the percentage of He in natural gas to increase from 0·15 to 0·33 as he went further west; the whole available supply he estimated at 2,000,000 cub. ft. per year. In the Bow Island district of Alberta the percentage is 0·36, the possible annual supply over 10,000,000 cub. ft. The Saskatchewan gas is less rich; in British Columbia some natural gas contains 99 per cent. of nitrogen and very little helium, whilst in the Ontario and Alberta gas methane makes up 80 per cent., ethane, butane, &c., are present sometimes to several per cent., and hydrogen is generally absent where helium is found. This is noteworthy, and the varying composition of the gases complicates the isolation of helium. In other parts of the Empire, Trinidad, New Zealand, as well as in Peru and Italy, helium seems not to occur in more than negligible quantities. Some springs in France contain up to 5 per cent. of helium; in the Lone Star Company gas, which was actually worked for helium in the United States, the helium percentage was only 0·9.

With the co-operation of the Société L'Air Liquide, Professor McLennan started in summer 1917 a small experimental plant at Hamilton, Ontario, on the suggestion of a committee consisting of Lord Fisher, Sir J. J. Thomson, Sir Charles A. Parsons, and Sir George Beilby. By that time, the United States had come in, and the Bureau of Mines was able to start work on a very different scale. The Hamilton plant obtained early in 1918 a 5 per cent. product, and later an 87 per cent. product; the compressor used had been sent over from Oldbury. There was no difficulty in principle, but great difficulty in securing proper plant and uniform material. New works were established in September, 1918, in the buildings of the Canadian Natural Gas and Light Company, of Calgary, which is connected with the Bow Island district by a 6-in. pipe line, 150 miles in length. A Claude rectifying column was adopted, but the apparatus was modified in various ways, which Professor McLennan explained very briefly by the aid of many diagrams; one of these we are able to reproduce herewith. After Professor McLennan's return from South Kensington, where he had been working, to Canada, the Calgary plant was run for four months till April, 1920; a run of three days or more dealt with, 500,000 cub. ft. of gas, which was reduced in the initial stage to 20,000 cub. ft. of 5 per cent. of helium, and in the second stage to 700 cub. ft. of 90 per cent. purity; the efficiency was raised from 60 per cent. to 80 per cent., and the purity finally to 97 per cent., 99 per cent. being attainable. But the local difficulties were great, and much time was spent in stopping leaks. For the final apparatus, every step in the development of which has been tested out, Professor McLennan suggested a capacity of 66,000 cub. ft. per hour to deal in two stages, at pressures of 40 atmospheres and of 20 or 30 atmospheres respectively, in six columns (to which two spare columns should be added). Such a plant should yield 10,500,000 cub. ft. of a purity of 97 per cent. per year, at a cost of 150,000*l.*



If we follow our diagram (not drawn to scale) of the final helium-column apparatus, on this page, from left to right, we notice first the heat exchanger Q; two of these are in use, and they are so arranged that the gas flow can be reversed (as in oxygen and nitrogen machines). The high pressure gas is in the outer casing, the return low-pressure gas in the small tubes. Next come the liquefier R, and the expansion engine S, both of the liquid-air type of machine; the first vaporiser and collecting pot U T, as in nitrogen columns, and the second vaporiser and pot W V above the first and of about one third the size of U; a rectification column X to stand a pressure of 10 atmospheres, not more than 2 ft. long, and about three-eighths the diameter of U or W; a vaporiser Y (of the dimensions of X), in which a partial vacuum is maintained; two purge bottles, Z_1 and Z_2 (centre and bottom of diagram); two heat exchangers I (on the right hand side of the diagram), similar to Q, but reversible, and only of

* The "Report on Some Sources of Helium in the British Empire," an octavo volume of 72 pages, has been published by the Department of Mines, Canada, since this article was written. It is drawn up by Professor McLennan, associated with Professors John Satterly, E. F. Burton, H. F. Dawes, Captain H. A. McTaggart, and Messrs. John Patterson and R. T. Elworthy. These gentlemen, we should state, analysed also the natural gases from foreign sources, and Mr. Patterson was in charge of the Calgary plant and largely responsible for the modifications of the rectifying column.

5 per cent. of its capacity; a vaporiser II, of the size of Y, to bear 50 atmospheres on its high-pressure side; a rectification column III, about 3 ft. long and half the diameter of X, also to bear 50 atmospheres; and a vaporiser IV, similar to II, but only of half its size. The letters A to N indicate the 14 control valves, the P_1, P_2, &c., the 11 purges, the L_1, L_2, &c., the 7 levels of the liquids, and numbers in circles like (1), &c., mark the gauges—11 in all. The positions of the thermocouples are also marked on the diagram.

The condensation of helium in this apparatus takes place in two processes; the arrows will enable us to understand the complex circulation. In the first process the compressed gas enters the exchangers Q through the valve A; leaving Q at the top, part of the gas goes through the liquefier R, the rest flows through the expansion engine S to the first pot T in which a pressure of 4 atmospheres liquefies most of the gas; this gas condenses in U. The uncondensed gas passes through valve H into V and W for further condensation. What remains gaseous flows through valve I to the bottom of the rectifying column X, and further through the condenser Y; the uncondensed portion, containing now about 5 per cent. of helium, leaves through the valve K (top of diagram) where the pressure is reduced nearly to atmospheric, flowing down the inner pipe of the heat exchanger Q and into a gasometer. The liquid which has collected in T and V is drained into the purge bottles Z_1 Z_2, which are made fairly long to prevent any escape of uncondensed gas. Through the valves D and E these liquids from Z_1 and Z_2 are purged into the vaporiser II, and Z_2 can further be purged through valve F into vaporiser Y. From II the liquid overflows into W, and from W itself into U. Some of the liquid in II can also be purged through valve G into Y, the coldest part of the apparatus in the first process, since liquid boils there under reduced pressure. The liquid condensing in this latter vaporiser flows through the rectification trays in X and is purged through the valve J into W. The gases evaporating from the liquids in U and W pass directly back to the liquefier R and from R further into Q. The gas liberated in vaporiser II flows together with the liquid down into W; while in Y evaporation takes place in a partial vacuum, the gas entering the vacuum pump through the heat exchanger Q, as shown in the diagram.

So far the gases and liquids in circulation are marked by arrows with bare shafts; the arrows explaining the second process are distinguished by a knob at the end of the shaft. The gas containing about 5 per cent. of helium drawn off in the first process, after having passed through valve K, at the bottom of Q, as mentioned, is recompressed to 30 atmospheres and re-enters the apparatus illustrated and the heat exchanger 1 (near the lower right-hand corner of the diagram). From I the gas passes to the top of condenser II—which is filled with the liquid from the first process approximately at the temperature of liquid methane, — 163 deg. C. There part of it, mostly nitrogen, is liquefied, the liquid and gas passing into the rectification column III; the liquid flows down through the trays in III to the collector at the bottom, while the gas passes up through the column and into the condenser IV. Here the rest of nitrogen is condensed, and the final product, a helium of 97 per cent., is drawn off through valve M.

Since a purity of 90 per cent. would not be sufficient for balloon-charging, Professor McLennan especially investigated also the purification of helium contaminated with air. The investigation necessitated many accessory researches. As helium does not enter into chemical reactions, the gas mixtures are tested by a silica balance (bulb $\frac{3}{4}$ in. diameter) by katharometers and by Jamin inferometers. The relative permeabilities to hydrogen and helium of rubbered balloon fabrics are 100 and 70; skin-lined fabrics are equally permeable to the two gases, wet cotton fabric is feebly permeable, soap films are highly permeable.

As regards the uses of helium, Professor McLennan pointed out that, for aeronautical purposes, we have to bear in mind the limitation imposed by the supply. Helium can be diluted with 15 per cent. and even 26 per cent. of hydrogen without becoming inflammable; but even that dilution would little increase the amount of balloon gas. Helium is utilised for filling incandescence signalling lamps and thermoionic valves; it is wanted for spectroscopical tests; it would make a valuable medium for high-tension switches now placed in oil; and it is invaluable for cryoscopic research. Liquid oxygen, nitrogen, hydrogen, helium bring us down to temperatures of 182·5 deg., 193·5 deg., 252·8 deg., 271 deg. or 272 deg. C. below zero respectively. At the lowest temperatures obtainable electric and thermal conductivity, magnetic properties, radiations, chemical photochemical and biological activities, &c., are all stimulated or suppressed to extraordinary degrees. The fundamental problems of science will always remain problems. Nobody doubts, however, that low-temperaturere search must help us on wonderfully. Low-temperature research has been carried on successfully in this country for years by Sir James Dewar and others. Yet the Empire does not possess a cryoscopic laboratory comparaable with those of Kamerlingh Onnes and of the Carnegie Institute of Washington. If helium is no longer wanted for balloons, it is all the more wanted for scientific purposes. Great Britain and Canada, Professor McLennan concluded, might reasonably be asked to run a helium supply station for several years, and to establish a cryoscopic laboratory. The equipment might cost 35,000*l.* and the maintenance absorb the interest on 150,000*l.* The proposal deserves earnest attention.

NOTES.

AWARD OF THE FRANKLIN MEDAL TO SIR CHARLES PARSONS.

THE July issue of the Journal of the Franklin Institute contains a report of the meeting at which Sir A. Geddes was given custody of the Franklin Medal awarded to Sir Charles Parsons "in recognition of his epoch-making success in the development and construction of the steam turbine, which has revolutionised the art of steam engineering, particularly in regard to the propulsion of mercantile and naval vessels, and the driving of electrical generators." This award is at once an honour to the Franklin Institute and to the recipient, whose right to be included amongst the great engineers of all time is indisputable. The honour has, however, been hardly earned. It was for years impossible to make engineers in general accept the steam turbine seriously, and in fact Sir Charles separated from his original partners owing to their becoming too discouraged to carry on. Past experience furnished no doubt some justification for their pessimism. The idea of the compound steam turbine was old, but had never been made a practical success. This was achieved solely by the ingenuity and insight of the new medallist, who overcame each mechanical difficulty in turn as it arose, and established certain principles of design, now followed and accepted wherever steam turbines are built. It is no exaggeration to say that the work of Sir Charles Parsons has halved the cost of producing electric power, and reduced in still greater proportion the capital cost of generating machinery. The problem solved was one of extraordinary difficulty since, as Mr. Ferranti has pointed out, the steam turbine is essentially a big unit machine, and is at a disadvantage when built in small sizes. Yet until Mr. Parsons made good with the small sizes there was, of course, no demand for large units. It may be added that the construction of the high-speed generators to be driven by the turbine constituted nearly as difficult a mechanical problem as the steam turbine itself, and required almost as much inventive ability, so that it was a double problem that was faced and solved by Sir Charles.

THE CROWN AND PATENTED INVENTIONS.

IT is well known that any Government Department may make, use or exercise an invention for the services of the Crown on terms which, either before or after the use of the invention, may be agreed on between the Government Department concerned and the patentee, subject to the approval of the Treasury. Previous to the coming into force of Section 8 of the Patents Act, 1919, if a patentee and the Government Department could not agree, the Treasury had the power to make the final decision, but this power was taken from the Treasury by the section mentioned, which came into force on April 23 last, and which substituted the Courts as the final arbiter. Last week, a motion came before Mr. Justice Sargant which raised some important points in regard to the matter. The motion was made on behalf of Mr. F. M. Hale, an engineer and owner of several patents relating to the manufacture of grenades and aircraft bombs. Mr. Hale presented a petition to the Treasury in order to ascertain what use the Government had made of his inventions, but the Treasury denied the validity of his patents or, if valid, that they had been infringed. As there was thus a dispute between the inventor and the Treasury, the patentee brought the matter before the Courts and asked for a decision as to whether the Court of the Treasury was the final arbiter. Mr. Justice Sargant decided that as the user of the inventions had been prior to the coming into force of the amending section (Section 8) the Treasury had the deciding voice. The denial by the Treasury of the validity of Mr. Hale's patents places him in a most unfortunate position, as he is denied compensation that might have been paid unless and until he establishes the validity of his patents before the ordinary tribunals of the country. Mr. Justice Sargant also had to decide whether the tribunal before whom claims under Section 8 had to be brought was the High Court generally, or a special judge appointed by the Lord Chancellor. The learned judge decided that the tribunal was the High Court and that any judge of that Court had jurisdiction under Section 8. The decision on the latter point does not appear to us to be correct, as Section 92 (2) of the 1907 Act provides that where a petition is referred or presented to the Court the Lord Chancellor is to select the judge to deal with the matter. In view of the importance of the matter, Mr. Hale is taking the matter to a higher court.

SCIENTIFIC AND INDUSTRIAL RESEARCH.—The Secretary, Department of Scientific and Industrial Research, announces that Professor Sir John Cadman, K.C.M.G. D.Sc., University of Birmingham; Mr. W. B. Hardy, Sec. R.S., Gonville and Caius College, Cambridge; and Professor Sydney Young, D.Sc., F.R.S., Trinity College, Dublin, have been appointed by an Order of Council dated June 24, 1920, to be members of the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research.

EMPIRE MOTOR FUELS.—The Empire Motor Fuels Committee of the Imperial Motor Transport Council has recently co-opted Mr. Sam Henshaw, F.I.C., (National Benzole Association), and Professor H. B. Dixon, F.R.S. (Manchester University), as additional members, and has appointed the following sub-committees: *Engineering*—Dr. W. R. Ormandy, D.Sc., F.I.C. (Chairman), Colonel D. J. Smith, O.B.E., M.I.A.E., Mr. G. W. Watson, M.I.Mech.E., M.I.A.E., Mr. G. J. Shave, M.I.Mech.E., M.I.A.E., Mr. F. G. Bristow, F.C.I.S., F.S.S., A.M.Inst.T. (Hon. Secretary). *Denaturation*—Sir Charles Bedford, LL.D., D.Sc. (Chairman), Dr. W. R. Ormandy, D.Sc., F.I.C., Mr. Sam Henshaw, F.I.C., Mr. F. G. Bristow, F.C.I.S., F.S.S., A.M.Inst.T. (Hon. Secretary). Sir James Dobbie, F.R.S., the Government chemist, has given the Committee permission to reprint and circulate his report, furnished to Mr. Walter Long's Committee last year, on denaturants and denaturing, and as from the first prox. the Committee will undertake its own research in these important branches of investigation.

STEEL RESEARCH.—The very extended research on automobile steels which has been carried out by the Research Committee of the Institution of Automobile Engineers has now been brought to a successful conclusion, and at a meeting held on the 21st inst. the report was finally approved. It is hoped that it will be ready for issue by about the end of August, when a further announcement in regard to price, &c., will be made. The report will contain a vast amount of information in regard to the physical properties of the ten automobile standard steels of which the specifications are given in British Engineering Standards Association Report No. 75, with coloured charts showing these properties under various heat treatments as represented by the tensile, Izod and Brinell tests. The work has been carried out by the Executive Sub-committee of which Mr. A. A. Remington was chairman up to a certain date, Mr. J. H. S. Dickenson assuming that office for the latter part of the period of research. The remainder of the members of the sub-committee were Messrs. Hy. Brearley, J. Wortley Fawcett, Brig.-General R. K. Bagnall-Wild, C.B.E., Major H. P. Philpot, and Captain E. W. Birch. The edition will be very limited and will be obtainable in the first place from the offices of the Institution of Automobile Engineers, 28, Victoria-street, London, S.W. 1.

LITERATURE.

Paper-making and its Machinery. Including chapters on the Tub-sizing of Paper, the Coating and Finishing of Art Paper, and the Coating of Photographic Paper. By T. W. CHALMERS, B.Sc., A.M.I.Mech.E. London: Constable and Co., Limited. [Price 26s. net.]

It is recognised that at the present time industrial science must be co-ordinated and intensified. The trained and collective mind must be concentrated on industries that have hitherto been led and guided by individual competency. Secrecy and isolation are neither desirable nor possible. The old order has to fit itself to hearty and sincere co-operation with new methods, and the material that has been accumulated by pioneers will render its fullest use when placed at the service of the whole community. Some new machinery is needed to secure the elimination of inferior processes and the introduction of improved technology. None is better calculated to effect this end than the examination and comparison of methods pursued in different localities and under different management. Our contemporary, *The Engineer*, has investigated the process of paper making, a trade that has been credited, but quite without sufficient evidence, with the desire to maintain its trade secrets intact, and the publication in book form of the series of articles which recently appeared in that journal, presenting a complete picture of the whole of the engineering processes, is a valuable contribution that will be appreciated by all who are interested in the operations. The dearth of literature on the subject can hardly be attributed to the prevalence of an unworthy secrecy, for the author found the leading British paper makers willing to furnish information, drawings and illustrations, representing the established and current practice. Publicity is commendable as criticism is illuminating, and imitation is hardly likely to be practised without introducing some change that will react beneficially.

In an introductory chapter, Mr. Chalmers gives a sketch of the history of paper making, a comparatively recent industry in this country. Introduced from the Continent in the early sixteenth century, apparently we have never been able to overtake the earlier start of our German rivals. Statistics show that before the war German exports of manufactured paper were twice as great as those from this country, while Austro-Hungary was no despicable competitor. The present high price of paper is in a great measure due to the loss of the German imports, as in normal years we received from that source paper of the value of one and a quarter millions sterling. It should not be difficult to capture some of the Continental trade. This chapter also gives an apercu of the several processes necessary to convert the incoherent raw material into a continuous paper web, the description of which in detail is the object of later sections. Those who have little or no acquaintance with the manufacture will be grateful for this summary. The mechanical processes, however, are not complicated, and throughout the operations the materials do not undergo any chemical change that might be difficult to follow. Two distinct steps have to be recognised, the preparation of the pulp, that is the disintegrated fibrous material, whether cotton, linen, bamboo, esparto grass or straw, for these and many other substances that contain cellulose have all been pressed into the service of the paper maker. The second operation embraces the conversion of this prepared pulp into paper of the finished form and surface required in commerce and the arts.

The first process in the cycle of operations consists in removing from the raw material the sand and dust and other adventitious foreign matter that might injure the mass. Such process is usual in many other trades as in milling for example, but in this case where old ropes may have to be torn asunder, further preparation is necessary by cutting, teasing out, and maceration, to permit the cleansed material to be handled efficiently in the digesting boiler. The disintegration and separation of the substance is carried out still further by boiling the cleansed fragments in an alkaline solution of caustic soda under considerable pressure, while the boiler is slowly rotated, on a horizontal axis. The general design for the machines fitted for this preliminary work is easily imagined, and the author describes and illustrates several standard types. But every paper-maker may find it necessary to introduce modifications to adapt these types to the varying nature of the stuff he has to handle in the course of his trade. For instance, if Esparto grass is a main ingredient rotation of the cylindrical boiler will not suffice, for under agitation this material forms a mass resisting complete permeation of the caustic soda lye, and the fat and grease to assist whose removal the alkali was added, are not removed.

The rough pulp, discoloured, and consisting of masses of unequal density, has next to undergo the process of washing, breaking, and bleaching: the first to remove and collect the alkali bath in the interests of economy, and to avoid the pollution of rivers. The breaking is intended to reduce the mass to uniform consistency by removing or breaking up the thickened portions, while the necessity for bleaching explains itself. Some of the operations may be carried out simultaneously in the same machine, and in any arrangement the machines however modified by experience and working with greater efficiency are all traceable to the beating engine known in the earlier and simpler form as "the hollander." The devices designed to increase the output, or claiming some peculiar merit, are admirably illustrated and adequately explained in the text.

The result of these breaking and bleaching processes is to leave a more or less white broken up fibrous substance, suspended in water but contaminated with surplus bleach liquor together with impurities, which the bleaching solution has created or extracted. The excess aqueous liquid must be drained off from the fibrous material and the residue washed to remove the impurities. Frequent washings play a large part in the preparation, but with cheaper papers these repetitions are apt to be rather perfunctorily performed, and the after result will be probably that the free acid left in the pulp will oxidise the cellulose, turning the paper yellow and making it brittle. But if bleaching liquor is added to cellulose, it is practically impossible to remove the traces completely, and when paper is required free from acid, as in filter papers, or for photographic purposes, the bleaching process is dispensed with, the necessary freedom from colour being secured by careful selection of the raw material. Many ingenious devices are used for pressing and concentrating the "half stuff," the improvements generally claiming the advantage of occupying smaller space, requiring less power to drive the machinery and yielding increased concentration of the pulp.

In the next operation, the pulp in which the fibres are now separated, but not broken, and are little altered in form and length from the original condition, has to be beaten and refined in a manner that while reducing the length of the fibres will permit them to be readily felted together so as to constitute a sheet of paper. To assist the felting power the fibres should be torn asunder rather than cut, and though the attention of the engineer has been riveted on producing a machine capable of effecting the object little general improvement has been effected on the method of the hollander of 250 years ago. Naturally there is greater economy in working, and the refining process in which the more stubborn particles that have resisted the action of beating are scissored between sets of moving and stationary blades is essentially one of economy, yet the principle and much of the mechanism necessitating the action of a knife drum, bedplate, back fall, and mid-feather is preserved. The function of the apparatus is different, but the process resembles that employed in the early breaking and washing machines. Beating is a skilled operation, the success of which depends mainly on the adjustment and sharpness of the knives on the drum, relatively to those on the bedplate, the speed with which the drum is driven and other variables, more or less under the control of the beaterman. The process of beating is comparatively lengthy, eight or more hours being given to cotton rag pulp, and perhaps half that time to esparto.

At this point it may be said that the paper is made, and in earlier times the beaten material was deposited on a wire frame or strainer, the even distribution being secured by careful manipulation of the workman. Indeed this process is still followed in the case of hand-made papers, the superiority of which is due to the felting fibres crossing each other at different angles, the frame being shaken in all directions. The size of the sheet is, however, strictly limited, and the continuous roll required by the modern printing press has to be produced by different machinery. This demand was first effectively supplied by the Fourdrinier machine, about the beginning of the last century, and has undergone many improvements since. It is in the description of this instrument and its main developments that Mr. Chalmers book will be found especially instructive. The outlined diagrams assist the finished illustrations very materially, and the detailed descriptions are very complete. In principle the machine is simple, but its recent extensions have grown complicated since distinct machines have been combined with the general plan. Following one diagram among many, it is seen that the pulp is delivered from the beating machine and made to flow through a sand trap and strainer, the latter being formed by a succession of very narrow cuts, or channels, through which the pulp can pass in the direction of the length, but not crosswise, with the result that any coarse pieces of fibre or impurities are prevented from travelling further. The strained pulp next passes a sluice designed to regulate the quantity of pulp flowing and consequently the thickness of the paper. This determined quantity passes through a breast box to an "endless" travelling band of wire cloth, the upper stretch of which is supported on a large number of small rollers. As the stuff is carried forward on this wire cloth much of its water drains away, and the fibres begin to felt together. The width of the finished paper is settled at this point by means of indiarubber deckle straps, two endless bands travelling with the wire cloth and regulating the breadth of the stream of pulp." Here we perceive the beginning of the formation of the paper and the further details must be arranged in various ways to promote the uniform drying of the paper, so that it may be lifted with safety from the wire cloth. This final act is accomplished by passing the paper between press rolls, the process being continued till the water is forced out and a strong sheet of paper is produced, though while saturated it may not be able to support its own weight. As the drying progresses, the paper is passed through smoothing rolls to remove all irregularities, and may be still further calendered, whereby the paper receives a high degree of polish, is toughened by consolidation, the tensile strength increased, and the thickness reduced some 40 per cent.

It can be easily imagined that the details of such a scheme are not simple, more especially as the material passing through the successive stages is not only very fragile, but continually shrinking, and precautions have to be taken to prevent a break in the web of paper. The whole process, however, is made both clear and interesting, and by dissecting the machinery into its component parts the author is able to make the description valuable to the engineer and technical expert. The usefulness is still further enhanced by the judicious selection of those points for fuller treatment which by reason of their intricacy or obscurity might prove stumbling blocks.

In addition to paper making properly so called, the author has thought it necessary or desirable to give some final chapters on the preparation of wood pulp and on the treatment of paper as used for some special purposes. Perhaps a justification for the former, if any be needed, is to be found in the fact that the wood pulp drying machine is almost identical in principle with the Fourdrinier. In any case the industry is so large and reacts on commerce in so many ways that an insight into its methods of working is both interesting and useful. Here one will learn that wood pulp is of various kinds and how these kinds differ, that it is a mistake to suppose that its employment is confined exclusively to the manufacture of cheaper papers, and the reasons for the poor quality of papers that is sometimes produced from mechanical wood pulp. The machinery for the reduction of this form of wood pulp is not generally made in this country, but in the prepara-

tion of soda and sulphite wood pulp, British industry is more directly interested, and several forms of mechanism are described and illustrated.

The uses of paper in trade and commerce involve many other industries than that of the paper maker, for it may be coated with various substances, and then the paper is simply the vehicle for carrying other materials, as carbon for typewriters, glass or sand for the carpenter's use, or metal for wrapping and decorative purposes. The author follows the paper through two applications that are not without interest. He traces the operations and the machinery necessary to give the smooth even surface usually associated with the term "art papers," and also the processes involved in depositing chemicals sensitive to light, on photographic papers. With laudable candour he explains that of the so-called art papers there are two kinds, the genuine and the imitation. The latter he dismisses as outside his province. This poor stuff is made to carry as much china clay as the pulp will hold, and the result is a paper if, as the author says with fine scorn, "such a term can be given to a substance of which more than one quarter is mineral matter only closely resembling a carefully prepared genuine paper." In a genuine art paper the surface only is coated with china clay and the ink of the printer's type or of the engraver's block does not penetrate into the fibrous part of the paper. It is possible under certain conditions of manufacture to remove the whole of the printed impression, by soaking the paper in warm water. In the course of preparation great care has to be exercised to prevent the surface coat being injured, in drying, or in some of the processes through which it is passed. The necessary machinery is very fully described This elaborate care is of even greater consequence in the coating of a photographic paper with salts of silver, and extends to the paper itself which must be as chemically pure as possible. There must be no free bleach, and the paper should be unsized, since the presence of any foreign chemicals would tend to reduce the silver salts. In particular, there must be no iron and this contamination is so difficult to prevent, while the pulp is passing through the stages of breaking and beating that it is usual to interpose a neutral "blanket" between the paper and the silver coating. This "blanket" is formed of barium sulphate, and besides its proper function of preventing contact with iron particles it improves the surface of the paper and makes good any deficiency of the bleaching process. A great amount of secrecy is preserved by photographic paper makers, so we will not attempt to penetrate behind the veil, but willingly acknowledge our indebtedness to one, who has been bold enough to make the attempt and given freely of the information he acquired.

Reports of the Progress of Applied Chemistry. Issued by the Society of Chemical Industry. Vol. IV—1919. London: The Society of Chemical Industry. [Price 12*s.* 6*d.* bound.]

THE various sections of the fourth annual report of the Progress of Applied Chemistry cover for the first time the complete range of subjects which are generally dealt with in the Journal of the Society of Chemical Industry, and which are summarised and supplemented in this very useful annual publication. In previous issues stress of circumstances had delayed the compilation of certain sections. Ceramics, Building Materials and Fermentation, included in this fourth volume, were held over last year, and the sections on Analysis and on Explosives now appear for the first time. Mr. C. A. Mitchell confines himself, in his report on Analytical Chemistry, to subjects of industrial importance leaving the summary of the general analytical practice to the annual report of the Chemical Society; the two chemical societies have been more successful than diplomats in agreeing upon the boundaries of their domains.

The 50 pages on Explosives, by Mr. W. Rentoul, of the Nobel Research Laboratory, Ardeer, deal with the period 1914 to 1919, but official restriction and the difficulty of obtaining the foreign literature are still patent. As regards high explosives a good deal of information was published last year at the British Association meeting (see our issues of October 24 and 31, 1919). For civil purposes the term "high explosives" means blasting agents, the supply of which became a knotty problem during the war. The potassium nitrate had to be replaced by the sodium salt, which is difficult for the manufacturer mainly owing to its hygroscopic character. Ammonium acetate, the principal cooling agent in safety explosives, was not available, and nitroglycerine could barely be spared. The blockade of cotton, on the other hand, did not hit the Central Powers as hard as had been expected. The Austrian Government relied entirely on the sulphate-cellulose of Ritter-Kellner, and though the tubular powder from wood pulp was less plastic and more sensitive to friction than cotton powders, the smaller loss of nitric acid incurred in the nitration of the wood material and the advantages of its cheapness, and also of greater purity and greater stability, are said to outweigh the drawbacks of wood even for permanent use. Liquid air and oxygen (oxy liquid) have found considerable application for blasting in American and German salt and coal mines, especially in Upper Silesia. The cartridges are filled with lampblack worked in liquid air; when salt is added to the detonators of safety explosives—to suppress the flame in coal mines—the loss of sensitiveness of the detonators due to evaporation may be rapid, unless the detonators are themselves made sensitive only when wet, so that the detonator and cartridge would simultaneously become useless; ordinary detonators would be ineffective, of course, at the low temperatures of liquid air. Though the explosive power of these cartridges increases with their oxygen percentage, Meves is said to have succeeded in rendering liquid air, rich in oxygen, more economical for these purposes than liquid oxygen itself. The question of detonators and of the initiation of the detonation in steps has claimed much attention during the war.

When we turn to other and more general problems we find the period of stagnation, which set in with the conclusion of the armistice, well characterised in the first Section on Plant and Machinery, now in charge of Dr. W. B. Davidson, of Newcastle-on-Tyne. The urgent demand for strong acids and for liquid ammonia dropped; there was a surplus of plant and of all kind of spares, and manufacturers of acid-resisting materials in particular were placed in a difficult position. Strikes increased the difficulties, but favoured also the adoption of labour-saving devices. Coke oven and gas works had to decide whether or not to go on with gas stripping (for benzene and toluene), which most of them continue, and to judge by the patent literature, at any rate, the problems of furnace improvement occupies many minds. In enamelled acid-proof ware Germany seems to retain her superiority, as also in chemical porcelain; according to Mr. W. J. Rees, of Sheffield (section on Ceramics) the British product remains only fairly satisfactory, and is not yet equal to Berlin porcelain as to resistance to sudden changes of temperature and as to glazes. German paper yarns, on the other hand, were merely a war makeshift, whilst the cellulose yarns, made from pulp which is not taken to the finished paper stage, seems to possess superior strength and to behave well in the dyeing bath. In Japan, Mr. S. S. Napper states in the section on Fibres and Textiles, paper is woven with hemp, silk and cotton; the Oriental Panama, produced by coating twisted paper with solutions of celluloid or nitro-cellulose, is also of Japanese origin. The use of cellulose has greatly expanded, and the search for new raw materials is ardent, though not particularly successful. One of the novelties, to which Dr. D. F. Twiss, of the Dunlop Rubber Company refers in the section on Indiarubber, has quite recently been mentioned in the Press. Mr. S. J. Peachy, M.Sc., of the Manchester College of Technology, vulcanises rubber in the cold instead of at about 135 deg. C., by treating the rubber successively with the two gases SO_2 and H_2S, which, reacting with one another, form water H_2O and finely-divided sulphur; the latter vulcanises the rubber which increases in viscosity and finally gelatinises. The main reaction and the fact, that sulphur dioxide alone reacts with rubber were known, but this cold vulcanisation of certain articles is novel. Peachy, it is said mixes in the manufacture of linoleum, wall paper, artificial leather, &c., the rubber with sawdust, paper, leather scrap, &c.; the advantage of the cold vulcanisation is, of course, that materials and especially also dyes can be used which would not bear heat. So far the new process seems to be limited to the materials mentioned.

Of other sections we will only mention that Professor A. J. Allmand, now of King's College, London, has taken charge of Electrochemistry, one of the industries to which the war had imparted an enormous stimulus. The fourth Report, we should say in conclusion, has grown into a volume of 632 pages, against the 495 pages of the third volume.

BOOKS RECEIVED.

United States Geological Survey. No. I: 2. *Platinum and Allied Metals in* 1917. By JAMES M. HILL. No. I: 11. *Gold, Silver, Copper, Lead and Zinc in the Eastern States in* 1918, *Mines Report.* By JAMES M. HILL. No. I: 12. *Gold, Silver, Copper, Lead and Zinc in Nevada in* 1918, *Mines Report.* By V. C. HEIKES. No. II: 5. *Magnesite in* 1917. By CHARLES G. YALE and RALPH W. STONE. No. II: 7. *Gypsum in* 1917. By RALPH W. STONE. No. II: 35. *Artificial Gas and By-Products in* 1915. By C. E. LESHER. Bulletins. No. 369. *Spirit Levelling in Mississippi,* 1901 *to* 1915, *inclusive.* R. B. MARSHALL, Chief Geographer. No. 640—H. *Gypsum in the Southern Part of the Bighorn Mountains, Wyoming.* By CHARLES T. LUPTON and D. DALE CONDIT. No. 641—H. *Geology of the Hound Creek District of the Great Falls Coal Field, Cascade County, Montana.* By V. H. BARNETT. No. 641—I. *Anticlines in Central Wyoming.* By C. J. HARES. No. 641—K. *Coals in the Area between Bon Air and Clifty, Tennessee.* By CHARLES BUTTS. No. 644. *Triangulation and Primary Traverse,* 1913–1915. R. B. MARSHALL, Chief Geographer. [Price 50 cents.] No. 647. *The Bull Mountain Coal Field, Musselshell and Yellowstone Counties, Montana.* By L. H. WOOLSEY, R. W. RICHARDS and C. T. LUPTON. [Price 50 cents.] No. 650. *Geographic Tables and Formulas.* Fourth edition, compiled by SAMUEL H. GANNETT. [Price 25 cents.] No. 657. *The Use of the Panoramic Camera in Topographic Surveying, with Notes on the Application of Photogrammetry to Aerial Surveys.* By JAMES W. BAYLEY. No. 660—A. *Notes on the Geology and Iron Ores of the Cuyuna District, Minnesota.* By E. C. HARDER and A. W. JOHNSTON. No. 660—D. *Tin Resources of the King's Mountain District, North Carolina and South Carolina.* By ARTHUR KEITH and D. B. STERRETT. No. 660—H. *The Antimonial Silver-Lead Veins of the Arabia District, Nevada.* By ADOLPH KNOPF. No. 660—J. *Possibilities for Manganese Ore on Certain Undeveloped Tracts in Shenandoah Valley, Virginia.* By D. F. HEWETT, G. W. STOSE, F. J. KATZ and H. D. MISER. No. 666. *Our Mineral Supplies.* H. D. MCCACKEY and E. F. BURCHARD, Geologists-in-charge. [Price 20 cents.] No. 690—A. *Zinc Carbonate and Related Copper Carbonate Ores at Ophir, Utah.* By G. F. LOUGHLIN. No. 692. *Mineral Resources of Alaska. Report on Progress of Investigations in* 1917. By G. C. MARTIN and others. No. 694. *Bibliography of the Metals of the Platinum Group—Platinum, Palladium, Iridium, Rhodium, Osmium, Ruthenium,* 1748–1917. By JAS. LEWIS HOWE and H. C. HOLTZ. No. 696. *A Catalogue of the Mesozoic and Cenozoic Plants of North America.* By F. H. KNOWLTON. [Price 60 cents.] No. 699. *The Porcupine Gold Placer District, Alaska.* By HENRY M. EAKIN. No. 710—C. *Deposits of Manganese Ore in Costa Rica and Panama.* By JULIAN D. SEARS. No. 710—D. *Deposits of Manganese Ore in Arizona.* By E. L. JONES, Junr., and F. L. RANSOME. No. 710—E. *Deposits of Manganese Ore in South-Eastern California.* By EDWARD L. JONES, Junr. No. 711—D. *Oil in the Warm Springs and Hamilton Domes near Thermopolis, Wyoming.* By A. J. COLLIER. Washington: Government Printing Office.

Kelly's Customs Tariffs of the World, 1920. London: Kelly's Directories, Limited. [Price 15*s.* net.]

The Directory of Shipowners, Shipbuilders and Marine Engineers, 1920. London: The Directory Publishing Company, Limited. [Price 20*s.* net.]

The "Electrician" Directory and Handbook of the Electrical Engineering and Allied Trades, 1920. Thirty-eighth edition. London: Benn Brothers, Limited. [Price 25*s.* net.]

The Concept of Nature. Tarner Lectures Delivered in Trinity College, November, 1919. By A. N. WHITEHEAD, Sc.D., F.R.S. Cambridge: The University Press. [Price 14*s.* net.]

Complete Practical Machinist. By JOSHUA ROSE, M.E. London: Hodder and Stoughton, Limited. [Price 18*s.* net.]

FRENCH NAVAL ARSENAL FOR PRIVATE INDUSTRY.—From information supplied to the Department of Overseas Trade from the British Consulate at Nantes, it appears that upon completion of the necessary preliminaries, and after Parliamentary sanction has been obtained, the Conseil Supérieur of the Navy proposes to hand over the arsenal at Lorient to private industry. Lorient will be reduced to a secondary base of operations in time of war and a centre for recruiting and instruction in time of peace. The change will furnish an opportunity for eventual industrial and economic expansion. The Chamber of Commerce of Morbihan, anticipating in this connection the development of trade at Lorient, has asked the Ministry of Marine to concede to it the administration and exploitation of the dry docks with a view to their use by merchant shipping.

SOME LINCOLNSHIRE OIL ENGINES.*

By F. H. LIVENS, of Lincoln, Member.

SINCE the last visit of the Institution of Mechanical Engineers to Lincoln in 1885, a most important engineering industry has developed in Great Britain, and particularly in this county, in the production of a new motive power, the influence of which throughout the world can hardly be estimated, namely, the employment of the heavier oils as liquid fuel admitted directly to the engine cylinder. It is true that there had been some use before 1885; for instance, the Brayton engine from America was introduced into this country by a Nottingham firm in 1878, whilst the Lenoir engine from France, and the Spiel engine from Germany arrived in 1883. The first ran on a heavy oil of a density corresponding to what we know as paraffin, but with a lower flashpoint than now stipulated, whilst the second and third required a petroleum spirit similar to the present petrol.

The Proceedings of this Institution are singularly barren of contributions as to this development, but there is excellent information to be found in many text-books (particularly "Gas and Petroleum Engines," Professor Robinson's 2nd Edition, 1902, and "The Gas, Petrol and Oil Engines," D. Clerk and G. A. Burls, Vol. II, 1913, and of course others).

The patent specifications of the period offer a wide field for research, fascinating when one is following the unfolding of a particular type, but too intricate for a paper of this kind; in fact, very often they are like Gratiano's reasons:—"two grains of wheat hid in two bushels of chaff; you shall seek all day ere you find them; and when you have them they are not worth the search." For the designer, however, there is much interest in retracing the more important routes which had to be explored, in noting the ingenuity, rather than invention, exercised in steering clear of those blocked from time to time by prior patents, and, in the earlier years particularly, the inexperience of the experimenters and their want of imagination in realising what might be attained.

The author would have liked to trace these influences thoroughly, but he can only allude to some in passing; further, whilst the original intention of the paper was to explore fully all that had been done in this country, even this he has been compelled to curtail, and to limit himself to the most important methods of vaporisation and ignition adopted, and to the increasing economy effected from time to time. Several names and variations are omitted consequently, and members will no doubt accept this explanation if the paper falls short of what might be expected.

The first real development began with the engine made by Priestman Bros., of Hull, which was based on the Eteve Patents, imported from France (1884), and became a practical motor when furnished with their own improvements of 1885-92. It was exhibited at the Royal Agricultural Show at Nottingham in 1888, and as many difficulties had to be overcome the credit attached to its manufacture was well deserved.

In December, 1891, a series of tests of a 5 h.p. engine by Professor Unwin showed a minimum consumption of 0·842 lb. per brake horse-power of Royal Daylight oil, 0·796 specific gravity and a thermal efficiency of 15·5 per cent.† The engine was four-cycle and the principle of working adopted may be described as the use of an exhaust gas heated vaporiser, separated from the engine cylinder, into which oil fuel was sprayed, by an adjustable air pressure jet, the main air for the charge being drawn with the mixture also through this vaporiser and the admission valve by the suction of the piston. The charge was compressed on the return stroke in the usual way and fired electrically; obviously the spraying of the oil and the proper proportioning of the air and the fuel oil required by the varying loads on the engine, were not easy problems, and involved delicate adjustments which were made more difficult by the unstable character of the charge contained in the detached reservoir and the length of the connecting passage to the cylinder.

In 1887 Knight commenced his series of devices for an engine for using "heavy hydro-carbons such as kerosine and paraffin lamp oils," in which again a vaporiser separated by a valve from the cylinder was used; there was no air-blast, and the chamber was heated at starting by a lamp, which afterwards could be more or less dispensed with. In 1891 this form developed into what afterwards became known as the "Trusty" engine, in which the vaporiser was a jacket round the combustion chamber and heat was imparted to its outer walls or through a chimney in the vaporiser, by the blow lamp at starting. Ignition was effected at first by an outside flame, burning constantly, but in the early "Trusty" engines the heat of the combustion chamber walls was relied upon after starting, which in turn was supplemented by an ignition tube or an internal igniter in the engines made in 1895 in Lincoln by Clayton and Shuttleworth, who then were licensees.

Other and simpler methods of working were being developed; in 1886 Akroyd Stuart and Binney devised means for "visibly measuring the combustible liquid and for mixing with the incoming air, also for vaporising both externally and in the cylinder." The engine was four-cycle and charge electrically fired, the fuel being of the spirit or petrol class. Other designs followed in 1888 and 1889, the last referring to heavy oil apparently, and providing a revolving series of blades to form fresh vaporising surfaces; relying on these evidently rather than on the heat of the charge. The great advance, however, came in the year following in the two complementary inventions of Stuart.

Unlike most of the previous experimenters (the "Spiel" engine being an exception) Stuart, who had worked on the principle of forming a vapour mixture with the air charge (Patent No. 7,146), drew his air-charge into a vaporising chamber in open communication with the cylinder, into which the fuel was delivered by a pump at about the end of the compression stroke, when the air was heated partly by the compression, partly by radiation from the highly-heated walls of the chamber and partly by the exhaust gases still remaining in the cylinder, the ignition being effected by the resulting temperature of the charge. This simple step was a distinct advance, in that pre-ignition of the charge, which hitherto had been a continual trouble, could be prevented by the correct timing of the fuel injection, and further it made possible the use of higher compression pressures. A few engines of 2 b.h.p., 4 b.h.p. and 6 b.h.p. were built at Bletchley using Shale oil and Russian oil of about 0·85 specific gravity. In 1891 Professor W. Robinson tested an engine developing

Fig. 1. 1891 TYPE. R. HORNSBY AND SONS, GRANTHAM.

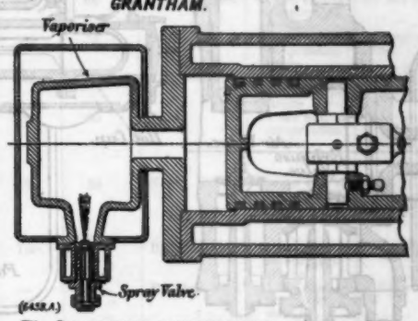


Fig. 2. 1896 TYPE. R. HORNSBY AND SONS, GRANTHAM.

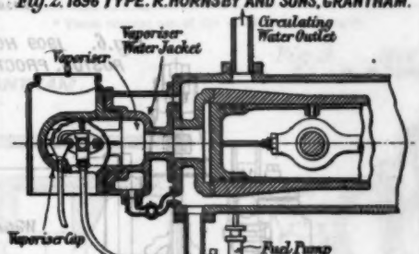
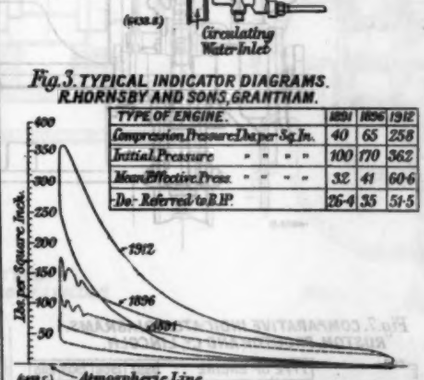


Fig. 3. TYPICAL INDICATOR DIAGRAMS. R. HORNSBY AND SONS, GRANTHAM.

TYPE OF ENGINE.	1891	1896	1912
Compression Pressure Lbs per Sq. In.	40	65	258
Initial Pressure " " "	100	170	362
Mean Effective Press. " " "	32	41	60·6
Do: Referred to B.H.P.	26·4	35	51·5



7·6 b.h.p. with a consumption of 1 lb. per b.h.p. hour, corresponding to an effective heat efficiency of about 13·5 p.c.

In the engine described in the second patent, No. 15,994, of 1890, the vaporising chamber was of similar form, in open communication with the cylinder by a narrow neck, the air being drawn, not through the chamber, but direct into the cylinder. Stress is laid both on this arrangement of air inlet and on the narrow communication between the vaporising chamber and the cylinder. The previous patent was silent upon the latter point, its value, therefore, had probably not been appreciated. The oil was injected by a pump into the vaporiser during the suction stroke, and not at about the end of the compression stroke, in order that it might have a longer time to vaporise. At the close of the compression stroke the charge in the vaporiser was fired, as before, by the temperature of compression and the vaporiser walls. This gave automatic ignition, dispensing with the lamp (except for starting) and the heated tube or electric ignition used hitherto.

The first design of Akroyd engine, of 1890, had possibly given trouble, on account of the low temperature of the vaporiser and incomplete splitting up of the fuel. It is interesting to note, therefore, the change in the position of the air valve in the later engine, which would increase the heat of the vaporiser. In a recent letter from Mr. Stuart to the editor of the *Motorship*, he states:—

"Little experience had been gained by the laymen at that early period regarding the working of oil engines, and this Akroyd engine cycle, patent No. 15,994, October 8, 1890, was developed to fill the then requirements of a comparatively low compression simple engine. These engines were very reliable and easily managed."

In June, 1891, the sole right to manufacture the "Stuart" engines under licence for the whole world was acquired by Richard Hornaby and Sons, Grantham, and it was mutually agreed that the type in conformity with patent No. 15,994 should be built and sold as the "Hornsby-Akroyd" oil engine. In February, 1892, Mr. Akroyd Stuart took out patent No. 3,909, for a vaporiser fitted in part with a water-jacket to regulate its temperature, as it had been found that the vaporiser became overheated after prolonged running on full load, and this the partial water-jacket could overcome. A series of tests was made upon a Hornsby-Akroyd engine by Professor Robinson in October and November, 1893, using "Russoline" oil of 0·824 specific gravity, and net calorific value of 18,600 British thermal units. At full working load of just under 5 b.h.p., the average consumption was 0·99 lb. per brake horse-power hour, equivalent to an effective thermal efficiency of about 14 per cent. The compression pressure was about 40 lb. per sq. in., with a mean brake effective pressure of 26·4 lb. per sq. in., and a maximum pressure of 100 lb. per sq. in.

Fig. 1 shows a sectional view of the engine as designed in 1891, and Fig. 2 the 1896 design in which part of the vaporiser is water-jacketed, and there is a separate hot cap, thus allowing the heat to be proportioned to suit the different grades of fuel. The second illustration is representative of the engines as built at the present day, up to 66 b.h.p., for using refined, crude or refuse oils.

Fig. 3 gives typical indicator diagrams of both types, also of a later engine which will be described presently. It will be noticed that in the 1896 design, owing to the partial water-jacketing of the vaporiser, it was possible to raise the compression pressure from 40 lb. per square inch to 65 lb. per square inch, whilst the mean brake effective pressure was raised from 26·4 lb. per square inch to 35 lb. per square inch at the working load of the engine; the effective thermal efficiency increased to 18 per cent. Thus originated an oil engine, which may be said to have achieved a wider reputation than any for simplicity, reliability and general usefulness.

Diesel patented his first engine in 1892, and, although this is not directly connected with the manufacture of oil engines in Lincolnshire, it is desirable to refer to his specification to show the position of his engine relative to present developments. The essential difference between the Diesel engine and the Stuart engine of 1890 lay in carrying the compression pressure much higher in order that the resulting temperature should well exceed that of the igniting point of the fuel; in fact, Diesel seems in his specification to lay so much stress on this claim that the essentials of a practical engine are lost sight of. Pulverised coal was to be the fuel, admitted at about the end of the compression stroke, and, according to Diesel, the combustion was to proceed gradually under constant pressure so that the diagram should have "a flat top," by the exact adjustment of the entering charge, and governing was to be effected by cutting off the fuel supply according to the load upon the engine. The use of liquid fuel was also contemplated, which was to be forced into the cylinder by means of a pump having a cushion of compressed air, at a pressure exceeding the compression pressure. It should be carefully noted there was no injection air with the charge, which was patented in 1895. He stated that "in the new process the highest pressure and the highest temperature are produced essentially not by combustion, but by mechanical compression. The combustion itself, in opposition to all hitherto known processes of combustion, does not produce any increase of temperature, or at least only an unessential one; the highest temperature (in the cylinder) is produced by the compression of air; it is, therefore, under control and will be kept correspondingly in moderate limits; as moreover the subsequent expansion cools the body of gas to a very high degree, it is obvious that no artificial cooling of the cylinder walls is necessary." There was, therefore, no water-jacket to the cylinder, nor any special lubrication for he says, "The mean temperature of the cylinder contents necessary for keeping the parts tight and lubricated, and in general for the practical working of the engine, is obtained solely by the process itself, whereby also it differs from all known processes."

It, no doubt, did differ, and to those who have struggled with overheated cylinders, cracked pistons and lubrication worries, it will not be surprising that the engine was a source of continual trouble and made no headway until its impractical features had been eliminated. In passing, it might be mentioned that in the old firegun, tinder was ignited by the heat produced by the sharp compression of air by a piston.

The foregoing remarks outline the position of the oil engine in the early "nineties," and little further advancement appears to have taken place until about the year 1904 when the Akroyd-Stuart patents of 1890 expired. Oil engines built in the county during the intervening time were improved in detail and became reliable power agents. Thermally, however, the advance was small.

The Stuart patents precluded other manufacturers from the use of a vaporiser communicating by an open neck with the working cylinder, and this was a vital point. It was necessary, therefore, to develop the engines on the lines of an external vaporiser communicating with the cylinder by a valve, such as had been done prior to 1890, and, although considerable ingenuity was shown in the devices employed to overcome the difficulty of automatically heating the vaporiser just enough for light running and yet not too much when on full load, some hand adjustment was the rule. Fig. 4 is representative of an engine of this type built in Lincoln first in 1897,

* Paper read before the Institution of Mechanical Engineers, at Lincoln, July 21, 1920.

† Proc., Inst.C.E., vol. cix, 1892.

ranging in sizes up to 30 brake horse-power working load with refined petroleum. In this the fuel oil was delivered by a measurer into a spirally shaped vaporiser situated in and heated by a loop in an extension of the combustion chamber; some air was drawn into the vaporiser with the fuel, and the mixture was admitted to the combustion chamber by a vapour-valve opened more or less simultaneously with the main air-valve of the cylinder.

The combined charge was compressed in the usual way, and fired by a by-pass or U-shaped tube kept at a much hotter temperature than the vaporiser or combustion-chamber (by the heat of the successive explosions) because of its being made of thinner metal and the asbestos insulation in the joints at each end. This design was simplified subsequently as to the vaporiser and an internal ignition tube was added.

The measurer was replaced by a fuel pump. Fig. 5 shows a later design of 1906 in which the general principle remains the same, but the vaporiser was in the form of a dish heated by an extension of the combustion chamber. The fuel was split up by being driven by the pump through a nozzle furnished with a spring-loaded valve. Ignition was effected by a hot cap. A water drip was added to control the heat. By suitably proportioning the areas of the vaporiser and the extension of the combustion chamber, and in particular the thickness of their walls, crude oil could be used as fuel, and the engine had an extended sale.

It could not use, however, refuse oils, and required some adjusting when passing from full to light load or *vice-versa*. Engines of this design were built in sizes up to 70 brake horse-power working load with a compression of about 45 lb. per square inch. The consumption of the larger engines was 0·55 lb. and 0·75 lb. per brake horse-power hour on refined and crude oils respectively, equivalent to thermal efficiencies of 25 per cent. and 18 per cent.

Extract of Professor Robinson's Report on Test made on a 050 "C.C." Class "O" Engine, which was in every respect a Standard Engine:—

	Oil used, Russian Crude.	Italian Refuse.
Load	Full	Full
Duration of trial	2 hours	2 hours	½ hour
Mean revolutions per minute	205·7	205·5	208·8
Net load on brake (mean) lb.	350	346	257·9
Brake horse-power	51·8	50·8	38·5
Oil used per hour (lb. weight)	23·25	24·9	18
Oil used per brake horse-power hour (lb.)	0·45	0·49	0·47
Thermal efficiency:—			
Calorific value of 1 lb. oil per cent.	100	100	100
Heat equivalent of work done in cylinder, per cent. on i.h.p.	40·4	37·5	41·6
Effective thermal efficiency, brake horse-power	31·4	29·5	30·8

During the test, samples of oils were taken, which gave the following values:—

	Russian crude.	Italian refuse.
Specific gravity at 60 deg. F.	0·875	0·947
Higher calorific value British Thermal unit per lb.	19,100	18,620
Latent heat of steam formed by hydrogen	1,100	1,020
Lower or effective heating value of 1 lb. weight oil in British thermal units	18,000	17,600

Another engine, differing somewhat in detail but

Fig. 4. 1897 TYPE. RUSTON, PROCTOR & CO., LINCOLN.

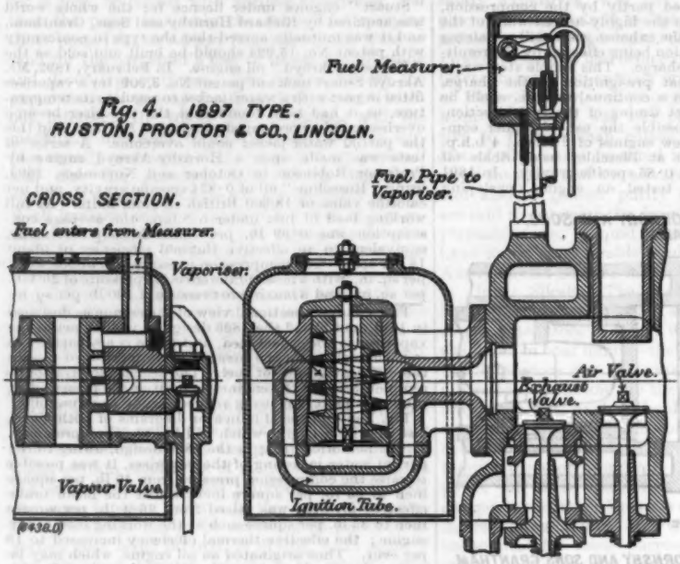


Fig. 5. 1906 TYPE. RUSTON, PROCTOR & CO., LINCOLN.

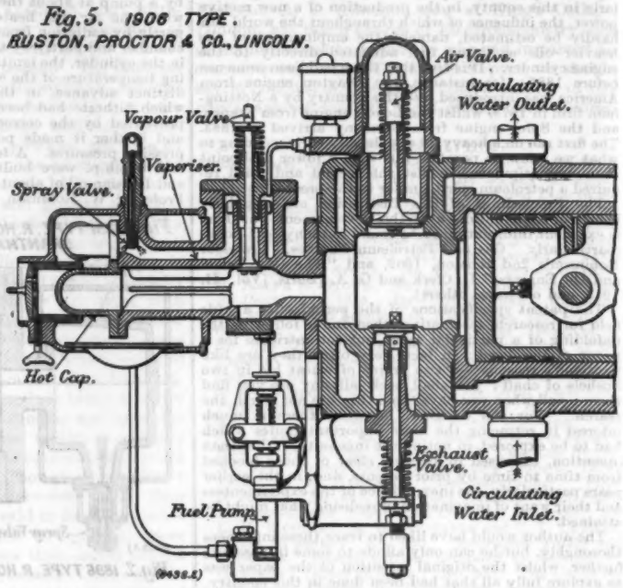


Fig. 6. 1909 HOT BULB TYPE. RUSTON, PROCTOR & CO., LINCOLN.

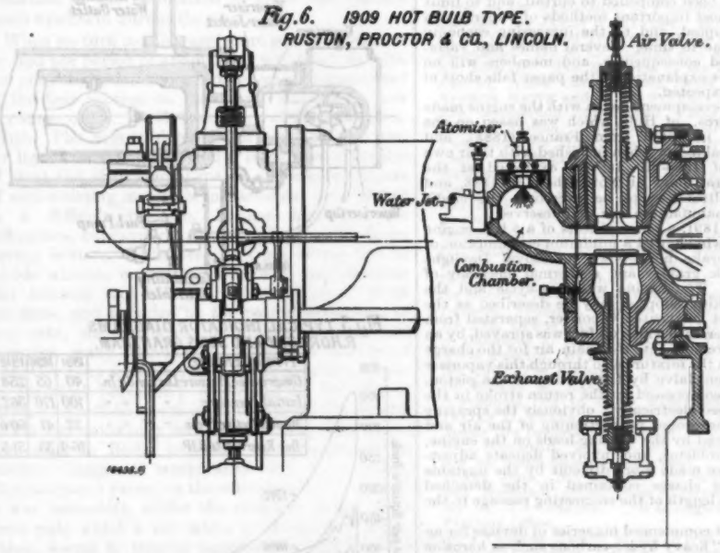
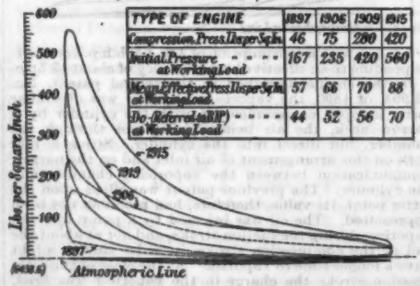


Fig. 7. COMPARATIVE INDICATOR DIAGRAMS. RUSTON, PROCTOR AND Co., LINCOLN.



TYPE OF ENGINE	1897	1906	1909	1915
Compression Press. lbs. per Sq. In.	46	75	280	420
Initial Pressure at Working Load	167	235	420	560
Mean Effective Press. lbs. per Sq. In. at Working Load	57	66	70	88
Do. (Referred to I.H.P.) at Working Load	44	52	56	70

On the expiry of the two Stuart patents in 1904 and the earlier Diesel patent of 1906, the way was open to designers to develop engines on the lines of either; possibly weak points in these patents could have been found, if bold action had been taken earlier; anyway, after these dates many new engines appeared. One of the most successful was developed by Ruston Proctor and Co. in 1909 (Fig. 6) having a compression of 280 lb. per square inch, in which the fuel was injected directly into the air compressed in a hot bulb combustion chamber at about the end of the compression stroke. This bulb was not water-jacketed, but its temperature was regulated by water injection, the amount of water required being about 0·2 lb. per b.h.p. hour, which with a small amount of air entered into it as vapour. A choke or neck was placed between the combustion chamber and the cylinder head, and the fuel charge was injected into the compressed-air charge, by the direct action of a fuel-pump driving the oil through an atomiser. This atomiser was essential to the engine, as on its action depended the efficiency obtained. It was copied in various directions. The fuel consumption with this engine showed a marked improvement, as evidenced by the tests made by Professor Robinson in 1910 (see above).

This particular engine had been run for some time, but an average figure for engines of 50 brake horse-power and upwards is about 0·5 lb. per brake horse-power hour, with fuel of 18,000 British thermal units per lb., giving a thermal efficiency of about 28 per cent. The M.E.P.* at working load was about 56 lb. per square inch, an improvement of about 4 lb. over their engine of 1906. Fig. 7 shows the comparative diagrams.

In 1908 the Grantham firm introduced an engine having a compression of 180 lb. and a sealing valve which shut off the vaporiser from the air and exhaust passages during the compression and explosion strokes; otherwise it was of the hot bulb type with the fuel sprayed into the compressed charge. Particulars of a test are given in the table on the opposite page.

This was followed in 1912 by their two-valve "R" type engine, Figs. 8 and 9, in which the compression pressure was increased to 280 lb. per square inch. This again was a reversion to the first Stuart patent as regards compressing the air-charge without the admixture of the fuel until the compression was complete, but there was added the partially cooled vaporiser and an

* Corresponding to the brake horse-power.

TABLE SHOWING THE DEVELOPMENT OF THE OIL ENGINE IN LINCOLNSHIRE.

Year of Trial.	B.H.P.	Consumption Lb. per B.H.P. Hour.	Effective Thermal Efficiency per Cent.	Authority.	Compression Pressure Lb. per Sq. Inch.	M.E.P. Lb. per Sq. In. Indicated.	Vaporiser Connection to Cylinder.	Method of Injection.	Method of Ignition.	Heat of Vaporiser Controlled by	Method of Starting.	Fuels Used.	Manufacturer.
1891	7·8	1·0	13·5	Professor Robinson			By open neck	At the end of compression	By hot vaporiser	None ..	Lamp ..	Refined ..	Akroyd Stuart, Bletchley.
1893	5	0·99	14	Professor Robinson	40	31·8	By open neck	During suction stroke	By hot vaporiser	None ..	Lamp ..	Russoline	R. Hornsby and Sons, Grantham 1891 type
1898	8	0·73	19	Makers ..	40	43	By passage and valve	During suction stroke	By hot "U" tube	None ..	Lamp ..	Refined ..	Ruston Proctor and Co. 1897 type.
1899	25	0·74	18	Professor Robinson	60	40·75	By open neck	During suction stroke	By hot cap ..	Partial water-jacket	Lamp ..	Russoline	R. Hornsby and Sons, Grantham, 1896 type.
1901	12	0·73	19	Cardiff trial ..	40	42	By passage and valve.	During suction stroke	By hot tube ..	Water drip	Lamp	Refined ..	Ruston Proctor and Co.
1906	85	0·78	18	Makers ..	45	49	By passage and valve.	During suction stroke	By hot tube	Water drip	Lamp ..	Crude oil	Ruston Proctor and Co., 1906 type.
1908	77	0·6	22·4	Makers ..	180	60	By open neck	At the end of compression stroke	By hot cap ..	Partial water-jacket	Lamp ..	Bornac liquid fuel	R. Hornsby and Sons, Grantham, 1908 type.
1910	51	0·45	31	Robinson ..	280	78	By open neck	At the end of compression stroke	By hot vaporiser	Water drip	Lamp ..	Russian crude	Ruston Proctor and Co., 1909 type.
1913	300	0·47	28·7	E. Calvert Finchley, U.D.C.	265	61·5	By open neck	At the end of compression stroke	By hot cap ..	Partial water-jacket	Lamp ..	Texas liquid	R. Hornsby and Sons, Grantham, 1912 type.
1914	25	0·48	30	Makers ..	420	80	None	At the end of compression stroke	Heat of compressed charge	None ..	From cold	Fuel oils of not less than 18,000 B.Th.U.	Ruston Proctor and Co.
1920	120	0·4	35	Makers ..	430	85	None	At the end of compression stroke	Heat of compressed charge	None ..	From cold	Fuel oils of not less than 18,000 B.Th.U.	Ruston Proctor and Co., 1915 type.
*1920	16	0·58	22·9	Makers ..	150	—	By open neck	At the end of compression stroke	By hot cap ..	Partial water-jacket	Lamp ..	Gasolenm	Marshall, Sons and Co., Gainsborough.
*1919	51	0·51	27·7	British Engine, B. & Elec. Insce. Co.	—	—	By open neck	At the end of compression stroke	By hot cap ..	Partial water-jacket	Lamp ..	Anglo-American fuel oil	Robey and Co., Lincoln.

* These engines are of the two-stroke cycle type.

Fig.8. 1912 TYPE "R". R. HORNSBY AND SONS, GRANTHAM.

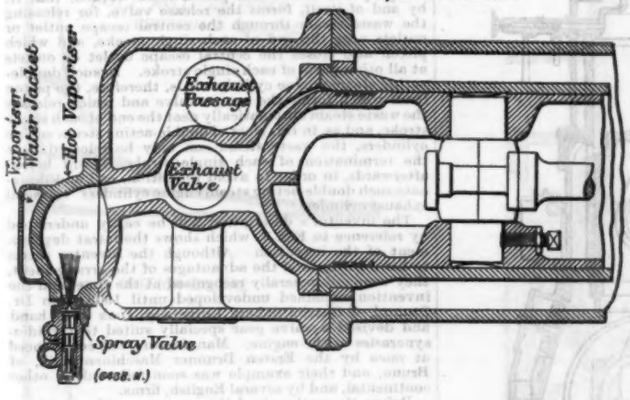


Fig.9. 1912 TYPE "R". R. HORNSBY AND SONS, GRANTHAM.

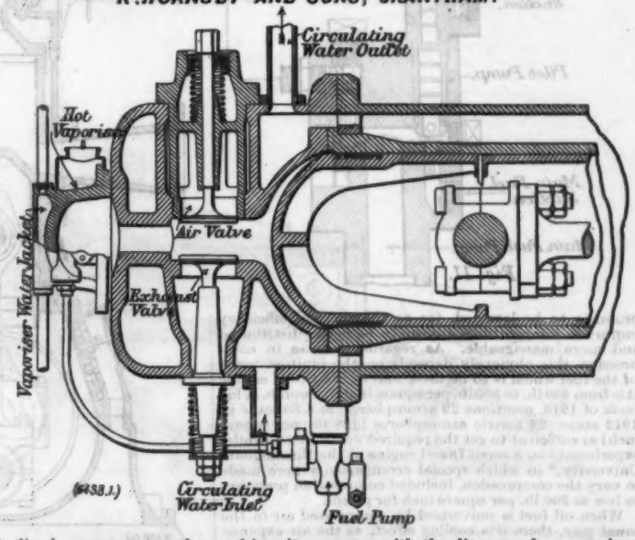
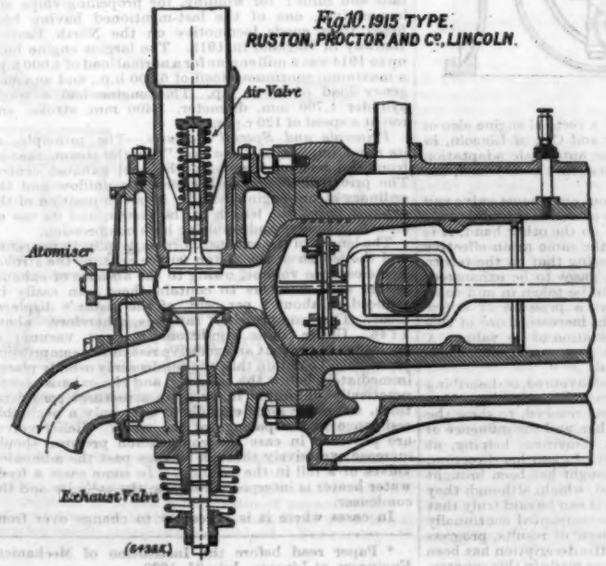


Fig.10. 1915 TYPE. RUSTON, PROCTOR AND Co., LINCOLN.



inclined passage to the cylinder into and against the wall of which the fuel was injected by the pump through a carefully proportioned nozzle. The liquid was thus finely sprayed and intimately mixed with the already compressed air-charge in a chamber which could be regulated as to its temperature by the partial water jacket. Ignition commences in the unjacketed portion, which is heated by a lamp before starting the engine.

An official test made upon a 320 brake horse-power two-cylinder engine using Texas liquid fuel of 0·9 specific gravity and 18,875 British thermal units, gave a consumption of 0·47 lb. per brake horse-power hour, equivalent to an efficiency of 29 per cent., and a mean brake effective pressure of 51·6 lb. Fig. 3 shows a typical indicator diagram from one of these engines and how it compares with the diagrams from previous engines of the same makers. This type is now built in sizes up to 170 brake horse-power per cylinder, making an engine of 340 brake horse-power working load, when coupled.

Another design of engine was developed at about this time at Stamford, having a compression pressure of 150 lb. per square inch for the main charge, and a more highly compressed air injection for the fuel, for which purpose a horizontal air pump attached to the engine bed was driven from the crankshaft. A small hot bulb started automatically the ignition of a supplementary spray which ignited in turn the spray of the main charge; and a lamp was required for starting. Trials made at Gloucester in 1909 show a consumption of 0·58 lb. per brake horse-power hour, when using Texas crude, which is equal to a thermal efficiency of about 24 per cent.

Although the engines just described show a marked advance upon their predecessors, the thermal efficiency was still lower than the best, as exemplified by the Diesel engine with a brake efficiency of about 35 per cent.; further, they required a lamp for starting, or adjustments were necessary to maintain the heat balance of the engine at varying loads, or they were limited as regards the grade of fuel oil which could be used.

With the knowledge of the efficiency which could be obtained by higher compression and more perfectly atomising the fuel, a further step was taken by Ruston Proctor and Co., and in 1912 experiments were begun, and data obtained by which an engine was designed in

1913, which gave remarkably good results and is still in regular service. It developed 25 brake horse-power with a consumption of 0·48 lb. of average fuel-oil per brake horse-power per hour. This was the forerunner of a series of which Fig. 10 shows a section. It starts from cold, without the use of a lamp, by compressed air of from 200 lb. per square inch to 300 lb. per square inch, stored in a receiver, with a drop usually of about 60 lb. per square inch; no adjustment is required of the temperature of the hot bulb or vaporiser, for there is none, and it is practically indifferent as to the grade of fuel oils which it has to use.

For tar oils a pilot ignition is fitted, and these can then be used as readily as ordinary fuel oil; the consumption of pilot oil is about 5 per cent. of the tar oil used at the rated working load. Although the working pressure has been increased, the wear of the major moving parts

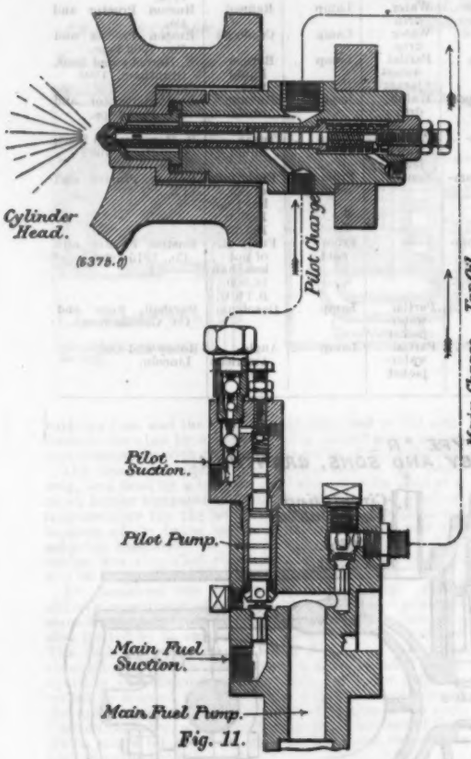


Fig. 11.

promises to be lessened, for as the thermal efficiency improves, temperatures appear to be better distributed and more manageable. As regards increase in compression, this obviously depends on the ignition point of the fuel which is to be used, and in the Diesel engine it is from 450 lb. to 500 lb. per square inch. Supino, in his book of 1913, mentions 29 atmospheres, and Sabathé in 1912 states 28 metric atmospheres (398 lb. per square inch) as sufficient to get the required combustion, whilst experiments on a small Diesel engine at the Birmingham University,* in which special arrangements were made to vary the compression, included compression pressures as low as 300 lb. per square inch for petrol.

When oil fuel is pulverised by compressed air in the usual way, there is a cooling effect, as the air expands from the receiver pressure down to the pressure of the compressed charge in the cylinder. Thirty atmospheres has been adopted in the new engine as a sufficient compression pressure for any fuel oil. The atomising is effected by forcibly compelling the liquid to lift its own spring-loaded needle valve which closes the opening to the injection nozzle, by the motion of a steep cam actuating the fuel pump plunger, as in the 1909 engine.

With pilot ignition the pilot oil is discharged by a needle-valve inside the main needle-valve, which is tubular. The pilot oil pump is actuated by the impulse of the fluid on a stepped plunger in the main fuel pump, so that perfect precedence is secured for the igniting jet. The construction is shown in Fig. 11. These engines are made up to a horse-power of 170 in a single cylinder, and the consumption of fuel oil ranges from 0·48 for 20 brake horse-power down to 0·4 lb. per brake horse-power per hour for the largest size, this being obtained with a fuel oil of 0·92 specific gravity, and not less than 18,000 British thermal units per lb., and is equivalent to a thermal efficiency of 30 per cent. to 35 per cent.

Finally, it can be claimed for this engine that it works with the same brake economy as the Diesel engine, without the complication of the two-stage air compressor for injecting the fuel; further, it is not possible for the kind of accident to happen to it which has on certain occasions wrecked Diesel engines, namely, the leakage or sticking up of the fuel-valve, causing compression to commence above atmospheric pressure, and pre-ignition, thereby producing an explosive pressure of twice or more the proper maximum.

The author wishes to thank Mr. Wans, who has been associated with him and has been responsible for the development of the engine, and for the valuable assistance in preparing this paper given by him, and also by Mr. James, whose long and intimate knowledge of the Grantham practice has been available.

Before closing, there is another type of oil engine which is a class to itself, namely, the two-stroke hot bulb. Of these, illustrations of two examples are given, by courtesy of the makers.

Fig. 12 illustrates a section of a horizontal engine by Marshall, Sons and Co., of Gainsborough, in which the fuel is injected into a partially water-jacketed hot bulb, heated by a lamp to start. A similar type of engine is also constructed by Clayton and Shuttleworth, of

Fig. 12. TWO-STROKE HOT BULB TYPE. MARSHALL, SONS & CO., GAINSBOROUGH.

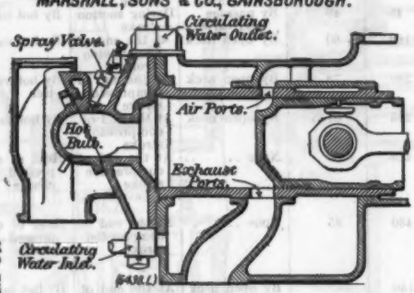
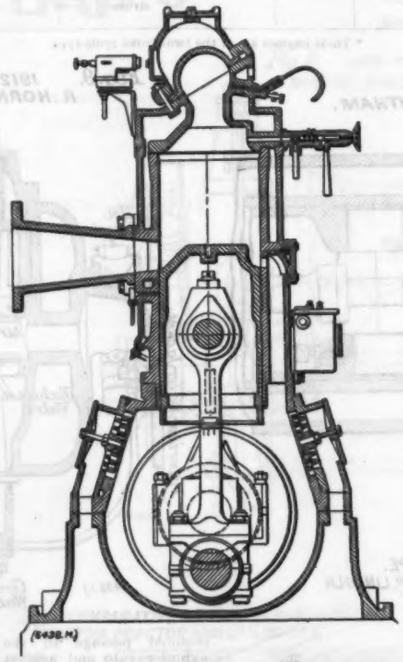


Fig. 13. TWO-STROKE HOT BULB TYPE. SECTIONAL SIDE ELEVATION. ROBEY AND Co. LINCOLN.



Lincoln. Fig. 13 is a section of a vertical engine also of the same type made by Robey and Co., of Lincoln, in which the usual difficulty of the automatic adaptation of the hot bulb temperature, the author is informed, has been overcome.

Two-cycle engines, being without an exhaust valve and half-time shaft, have fewer parts as well as the advantage of an impulse each revolution; on the other hand, it is impossible to get in the piston the same mean effective pressure (as in the four-cycle) seeing that on the return stroke not only have the spent gases to be exhausted, but the fresh charge of air has to be taken in and compressed, this being delivered at a pressure of a few pounds from the crankcase. The increasing use of this type indicates a growing appreciation of its value. A table is appended showing the progressive efficiencies obtained by the engines described.

Summing up, the author has endeavoured, in describing the types put before you, to trace the steps by which the present-day designs have been reached, to show the connection of these with each other, and the influence of one invention on its successor, sometimes helping, at other times compelling, a departure in another direction. An immense amount of hard thought has been brought to bear on the problems involved, which, although they seem simple, are so complex that it can be said truly that unless this thought had been accompanied continually by patient testing and comparison of results, progress would not have been effected. His description has been limited to some only of the engines made in this country, and mainly to those of which he has the fuller knowledge, but simultaneously developments of the four-cycle engine have taken place elsewhere in this country, on the Continent and in America, whilst the two-cycle type has been made very extensively abroad.

The tendency to-day is to save time and labour, so that starting devices will be demanded increasingly. For instance, the 1906 pattern engine described has been fitted successfully with an electrically-heated vaporiser and electric ignition, and can in a few minutes be started by moving a switch only. Even this interval, however, may be eliminated; there are paraffin engines which can be started on petrol like a motor car; the larger engines of the 1915 type start from cold by compressed air, as already described; and another device consists of a spray electrically ignited, and compressed air. Whilst the oil engine has increased in thermal efficiency during the period under review, it has gained in reliability and convenience to the user, and mechanically its advance has been still more important.

* Proceedings, Inst. C.E., clxxix, 1910.

THE UNIFLOW STEAM ENGINE.*

By F. B. PERRY, of Lincoln, Member.

HAVING regard to the high price of all classes of fuel at the present time and the consequent necessity of reducing consumption to a minimum, it is thought that a short paper on the history, principle of working, and details of construction of the uniflow engine, the latest development of the reciprocating steam engine, may be of interest.

History.—The uniflow engine was invented in this country in 1885 by T. J. Todd. Quoting from the specification, the object of the invention was "to produce a double-acting steam engine which shall work more efficiently, which shall produce and maintain within itself an improved graduation of temperature extending from each of its two hot inlets to its common central cold outlet, which shall cause less condensation of the entering steam, and which shall work with greater economy than has hitherto been the case." The invention is described as follows:—"In the first place I take a double-acting steam engine cylinder of that type which has one or more outlet openings placed at or near its longitudinal centre, and which has also a piston so proportioned in length and which piston is also fitted in some cases with self-contained internal escape ports, and which piston is so worked, that it, by and of itself, forms the release valve, for releasing the waste steam through the central escape outlet or outlets near the end of each single stroke, and which piston also closes the central escape outlet or outlets at all other parts of each single stroke. In such double-acting steam engine cylinders it is, therefore, the piston itself which forms the escape valve and which releases the waste steam automatically near the end of each single stroke, and as, in this class of double-acting steam engine cylinders, the waste steam can only be released near the termination of each single stroke, I will herein afterwards, in order to avoid repetition, call and designate such double-acting steam engine cylinders 'terminal exhaust cylinders.'"

The inventor's description will be easily understood by reference to Fig. 1, which shows the latest development of the invention. Although the inventor seems to have understood the advantages of the arrangement, they were not generally recognised at the time, and the invention remained undeveloped until 1908 when Dr. Stumpf, of Charlottenberg University, took it in hand and devised a valve gear specially suited to the idiosyncrasies of the engine. Manufacture was commenced at once by the Ersten Brunner Maschinenfabrik, of Brunn, and their example was soon followed by other continental, and by several English, firms.

Before the outbreak of the war, several hundred engines had been built and set to work for driving generators, fans and mills; for winding, for propelling ships and locomotives, one of the last-mentioned having been fitted to a goods locomotive on the North Eastern Railway in England in 1913. The largest engine built up to 1914 was a mill engine for a normal load of 4,000 h.p., a maximum continuous load of 6,000 h.p., and an emergency load of 8,000 h.p. This engine had a single cylinder 1,700 mm. diameter, 1,400 mm. stroke, and ran at a speed of 120 r.p.m.

Principle and Special Features.—The principle, as its name implies, is "one flow" for the steam, that is, from the hot inlet ends to the cool exhaust centre. The principal difference between the uniflow and the ordinary steam engine cylinder is in the position of the exhaust ports, the length of the piston, and its use as an exhaust valve and resulting high compression.

The length of the exhaust ports is usually 10 per cent., and the length of the piston 90 per cent. of the stroke. The clearance volume, owing to the absence of exhaust valves and chambers to contain them, can easily be reduced to about 2 per cent. of the piston's displacement. The compression ratio is, therefore, about 1:46. Under these conditions a good vacuum is necessary to prevent an excessive rise in the compression pressure. To obtain this, the condenser is usually placed immediately below the cylinder, and the exhaust ports, practically unlimited in area by structural considerations, are made large enough to offer only a negligible resistance to the passage of the steam. Relief valves are provided in case the compression pressure should increase excessively through leakage past the admission valves or a fall in the vacuum. In some cases a feed-water heater is interposed between the cylinder and the condenser.

In cases where it is necessary to change over from

* Paper read before the Institution of Mechanical Engineers, at Lincoln, July 21, 1920.

condensing to non-condensing, it has been usual to provide an additional clearance space in each cylinder-cover communicating with the cylinder through a valve which is closed when working condensing. This provision, however, is only suitable for temporary non-condensing, working as the enlarged clearance space and surface are inimical to economy. The best uniflow engines are now fitted with an arrangement by which they can work economically non-condensing, as the same small clearance space and surface is maintained, whether working condensing or non-condensing. In locomotive engines of the uniflow type special pistons have been used to give sufficient clearance space.

Another peculiarity of the uniflow engine is the early cut-off required to obtain a high ratio of expansion in a single cylinder. With 170 lb. pressure, 8 per cent. to 10 per cent. cut-off is required for full load. For cutting off so early a trip-gear is unsuitable, and a powerful and highly sensitive governor is necessary to control the positive valve-gear needed. The early cut-off in a cylinder large enough to give the required ratio of expansion implies a high initial load upon the piston, and consequently heavy working parts. The weight of these parts, however, is not without advantage, inasmuch as their inertia reduces the stresses on them and tends to equalise the turning effort throughout the revolution.

Advantages of the Uniflow Engine.—(1) *Economy.*—The results of tests for steam consumption show that, with 180 lb. boiler pressure and 200 deg. F. superheat, consumptions of 10·5 lb. and 10 lb. per indicated horse-power hour can be obtained at full load from engines developing 500 i.h.p. and 1,500 i.h.p. respectively. These low rates of consumption are due mainly to reduction of cylinder condensation resulting from the high temperature of the cylinder-ends, the position of the exhaust ports, the reduction of clearance surface and volume, and the high compression. The temperature of the cylinder metal varies from point to point along the bore, from the hot end where steam is admitted to the cooler middle where the exhaust ports are located, comparably with the temperature of the steam during admission and expansion. Indeed, the temperature gradient in the metal might be represented roughly by the admission and expansion lines on the indicator diagram.

Readings taken from a cylinder close to the inside surfaces of the cover and barrel have given the following temperatures—cover, 400 deg. F.; barrel half-way between cover and exhaust ports, 250 deg. F.; at middle near exhaust ports, 160 deg. F. So marked is this temperature gradient that, to prevent trouble in working, it is necessary to bore "uniflow" cylinders barrel shaped when cold, that is, larger in diameter at the middle than at the ends. The barrel temperatures vary very little when working either with saturated or superheated steam, due to the early cut-off, thus making this type of engine particularly suitable for superheated steam.

The high diagram factor obtained by the suppression of the losses which occur between the cylinders and in the receivers of multi-cylinder compound engines contributes to economy, Figs 2 and 3, also the compressed steam at approximately admission pressure, and the cylinder-ends which are kept hot by live steam flowing through the cylinder covers.

(2) *Flexibility.*—The steam consumption per brake horse-power hour at full load is low, owing to the small number of glands and working parts absorbing power in overcoming friction, nor does it increase appreciably with reduction or increase of load. At three-quarter load, it is practically the same as at full load; at half-load and at 25 per cent. over-load it increases by about 5 per cent. of the full-load consumption.

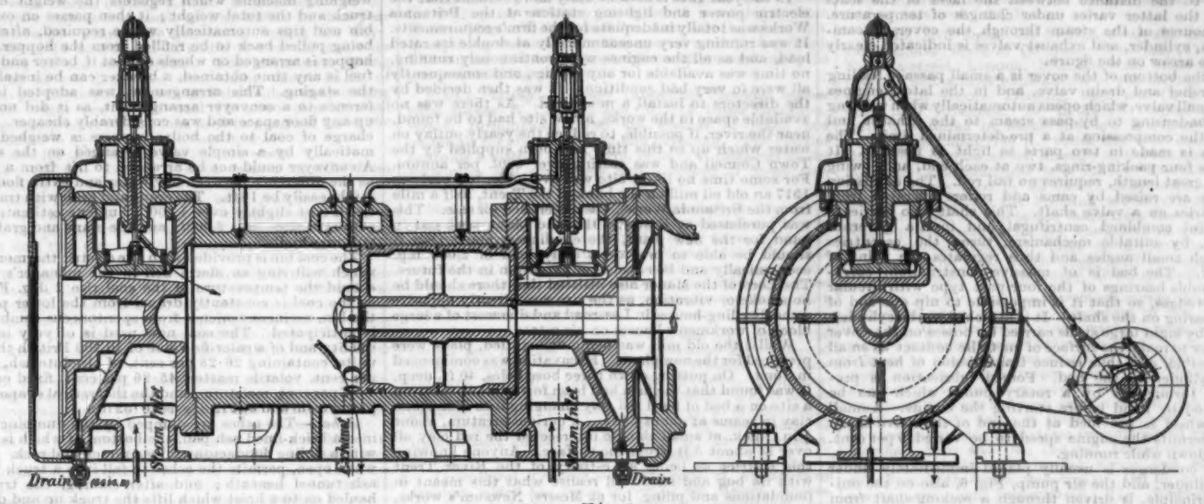
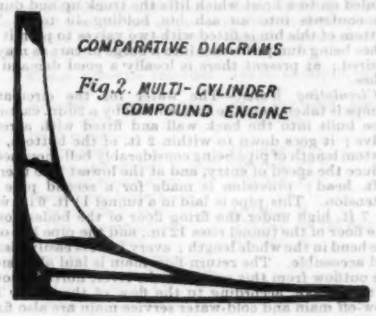
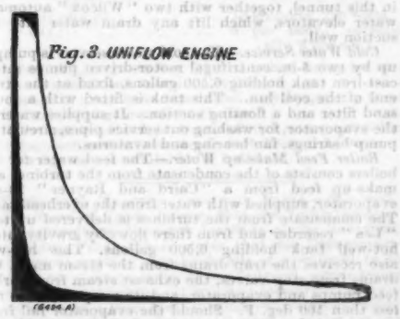
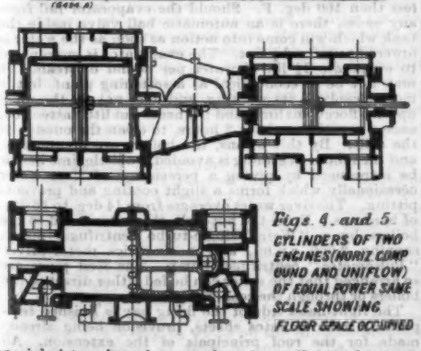


FIG. 1.







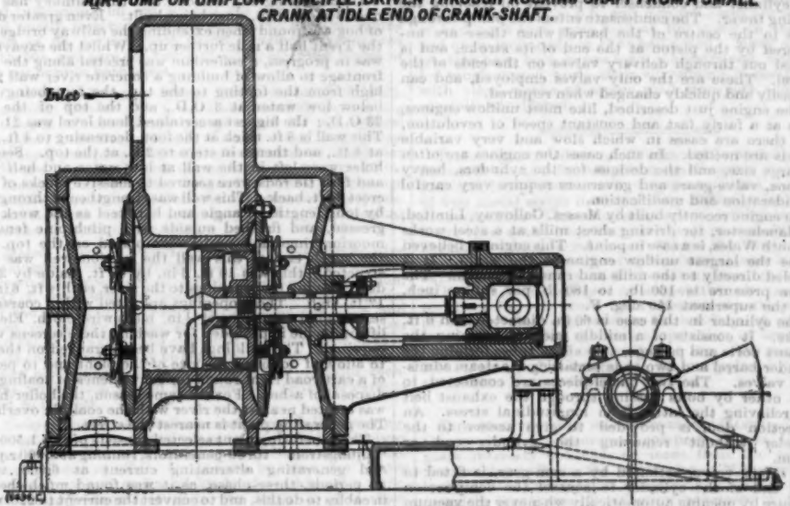


FIG. 6.

(3) *Speed-Control.*—It is claimed that the uniflow engine is specially adapted to give steady turning under either uniform or fluctuating loads, first because the indicator diagrams when corrected by the forces required to accelerate and retard the heavy reciprocating parts show a fairly uniform effective pressure on the crank-pin, and, secondly, because the whole of the power is developed in one cylinder, so that any change in the position of the governor produces its full effect in a single stroke.

(4) *Upkeep.*—Compared with a multi-cylinder compound engine, which is its nearest equivalent for economy, the cost of upkeep, oil and stores will be greatly reduced owing to the extreme simplicity of this engine and the small number of working parts.

(5) *Floor Space and Foundations.*—As will be seen from Figs. 4 and 5 (annexed), which represent the cylinders of two engines of equal power drawn to the same scale, the floor space occupied by the uniflow engine is less than that required by the tandem (or any other multi-cylinder) horizontal compound engine. The foundations will also be smaller and less costly than for a compound engine.

Details of Design.—Having dealt thus briefly with the history, special features, and advantages of uniflow engines in general, the author would add a short description of two of these engines. The first was built by Messrs. Robey and Co., Limited.* It is of 1,100 i.h.p., and drives a generator at a speed of 120 r.p.m.,

* See also page 104 *ante*.

with an over-load capacity of 25 per cent. for two hours, and of 50 per cent. for a few minutes. The steam pressure is 200 lb. per square inch, and the superheat 200 deg. F.

The cylinder, 35 in. diameter by 40 in. stroke, consists, as shown by Fig. 1, on page 163, of a barrel, a plain casting, carrying only the exhaust belt and two small brackets for bolting to the baseplates, and of two end-covers containing the steam valves. These last are double beat of large diameter and small lift, the upper part being movable relatively to the lower, so that the distance between the two valve faces can always adjust itself to the distance between the faces of the seats when the latter varies under changes of temperature. The course of the steam through the covers, steam-valves, cylinder, and exhaust valves is indicated clearly by the arrow on the figure.

In the bottom of the cover is a small passage leading to a relief and drain valve, and in the latest engines to a small valve, which opens automatically when working non-condensing to by-pass steam to the exhaust and keep the compression at a pre-determined limit. The piston is made in two parts as light as possible. It carries four packing-rings, two at each end, and, owing to its great length, requires no tail rod. The admission valves are raised by cams and rollers operated from eccentrics on a valve shaft. This shaft also carries a powerful combined centrifugal and inertia governor which, by suitable mechanism, turns the eccentrics through small angles and thus regulates the point of cut-off. The bed is of massive construction, carrying double bearings of the four-part type with circular back wedges, so that it is impossible to nip one end of the bearing on the shaft. It is attached to the cylinder-cover by eight large studs carried by bosses on the cover in order to make the surface of metallic contact as small as possible, and thus reduce transmission of heat from the cylinder to the bed. Forced lubrication is provided throughout by a rotary pump which can be operated by hand before starting the engine. A small hand-wheel is provided at the end of the valve shaft. This permits the engine speed to be varied 5 per cent. up or down while running.

The condenser is usually placed immediately under the cylinder, and the air pump, Fig. 6, also on the uniflow principle, is driven through a rocking-shaft from a small crank at the idle end of the crankshaft. On the engine illustrated an oil-extractor is placed between the cylinder and condenser to prevent oil reaching the cooling tower. The condensate enters the pump through slots in the centre of the barrel when these are uncovered by the piston at the end of its stroke, and is forced out through delivery valves on the ends of the barrel. These are the only valves employed, and can be easily and quickly changed when required.

The engine just described, like most uniflow engines, runs at a fairly fast and constant speed of revolution, but there are cases in which slow and very variable speeds are needed. In such cases the engines are often of large size, and the designs for the cylinders, heavy pistons, valve-gears and governors require very careful consideration and modification.

An engine recently built by Messrs. Galloway, Limited, of Manchester, for driving sheet mills at a steel works in South Wales, is a case in point. This engine is believed to be the largest uniflow engine in the world. It is coupled directly to the mills and runs at 28 r.p.m. The steam pressure is 160 lb. to 180 lb. per square inch, and the superheat 150 deg. F.

The cylinder in this case is 60 in. diameter with 6 ft. stroke. It consists of a middle piece containing the exhaust ports and passage, two short tubes forming the cylinder-barrel and two ends containing the steam admission valves. The two barrel-pieces are connected to each other by bolts passing through the exhaust belt and relieving the latter from longitudinal stress. An inspection door is provided to give access to the cylinder without removing the cylinder-end or piston.

A safety valve, actuated by a cam-gear, is fitted to each end of the cylinder to control the compression pressure by opening automatically whenever the vacuum falls. When starting the engine, the valve is open and operates till it closes automatically when the vacuum is formed. The piston is fitted with four rings like that already described, and is provided with a number of slippers flexibly supported and capable of independent radial movement to meet changes in the cylinder diameter due to change of temperature. The internal faces of the covers and the piston faces are polished to reduce condensation losses. The admission valves are of cast-iron, double beat, so constructed as to remain tight under all temperatures. Each valve is driven by an eccentric carried on a valve shaft, the cut-off being determined by the position of a sliding block in a vibrating link.

A centrifugal governor, acting through a floating lever device, and controlling the small balanced piston-valve of an oil-pressure servo-motor cylinder, determines the position of the block.

The piston-rod cross-head is of mild steel with shoes lined with white metal and phosphor-bronze steps, the housing for these being cut out of the solid. The connecting-rod is forked at the cross-head end, but solid at the big end with phosphor-bronze steps adjustable by a wedge. The crankshaft is carried on two bearings and the crank is overhung. The flywheel, carried between the crankshaft bearings, is 32 ft. diameter and weighs 160 tons. The main bearings and the crank-pin are lubricated with stiff grease instead of oil, at the request of the owners of the engine.

In conclusion, the author ventures to express the hope that his paper may have helped to convince the members of the simplicity, economy, and advantages of the uniflow engine.

NOTE ON NEW POWER STATION FOR MESSRS. MARSHALL, SONS AND CO., GAINSBOROUGH.*

By F. J. CRIBB, of Gainsborough, Member.

[In our issue of May 21 (page 670) we gave a fully illustrated description of the power station dealt with in this paper, which contains interesting additional matter; but it is not necessary to reproduce the illustrations included by Mr. Cribb in his paper as these do not differ from those already given in ENGINEERING.]

IN the year 1916 it became daily more evident that the electric power and lighting station at the Britannia Works was totally inadequate for the firm's requirements. It was running very uneconomically at double its rated load, and as all the engines were continuously running, no time was available for any repairs, and consequently all were in very bad condition. It was then decided by the directors to install a new plant. As there was no available space in the works, a new site had to be found, near the river, if possible, to reduce the yearly outlay on water which up to this time had been supplied by the Town Council and was costing over 800*l.* per annum. For some time no likely site was available, but early in 1917 an old oil mill on the bank of the Trent, half a mile from the Britannia Works, was advertised for sale. This was purchased at Easter, 1917, and plans were put in hand for the new plant, the conditions being that it should be able to provide a daily load of 2,000 h.p. economically and be capable of extension in the future. The Lord of the Manor also insisted that there should be no smoke or vibration, as the site was directly opposite some dwelling-houses in Lea-road and due west of a large block of workmen's houses on his estate.

Whilst the old mill was being dismantled, plans were prepared for the new plant. Excavation was commenced in June. On putting down three bore holes, 40 ft. deep, it was found that the firm had been fortunate in securing a site on a bed of hard red clay changing into blue stone clay in seams at about 25 ft. A curious stratum, about ½ in. thick, of small shingle intersected the red clay all over at about 5 ft. from the surface. Anyone knowing this district as being an estuary of the River Trent with its bog and sand will realise what this meant in foundations and piling, for at Messrs. Newsum's works, about 400 yards further up the river, two 24-ft. piles on end were driven down under the site for a chimney without finding any bottom, and the chimney has gone over 8 in. to 10 in. since being built. Even greater depth of bog was found when extending the railway bridge over the Trent half a mile further up. Whilst the excavation was in progress, a cofferdam was erected along the river frontage to allow of building a concrete river wall 26 ft. high from the footing to the top, the foot being 6 ft. below low water at 3 O.D., and the top of the wall 23 O.D.; the highest ascertained flood level was 21 O.D. This wall is 8 ft. thick at the foot, decreasing to 4 ft. 6 in. at 4 ft., and thence in steps to 2 ft. at the top. Seeping holes were left in the wall at low water and half tide, and four tie rods were secured to massive blocks of concreet 34 ft. back. This wall was strengthened throughout by long lengths of angle and bar steel as the work progressed, and finished outside with pitch-pine fenders; mooring rings and posts were placed on the top. At the south end of this wall the suction well was constructed; this was 10 ft. 6 in. by 13 ft. inside by 30 ft. deep, having two openings to the river, each 4 ft. 6 in. by 12 ft. high. These openings are fitted with a coarse bar screen and two screens of ¼ in. mesh wire cloth. Electric lifting tackle is provided for washing these screens when required. The buildings have been arranged on the site to allow of doubling the size of the plant and to permit of a cart-road right round for convenience of coaling and disposal of ashes. For the same reason, the boiler-house was erected nearest the river with the coal-bin overhead. The generating plant is nearest the street.

The generating plant selected consists of two 1,500-kw. "Ljungström" turbo-generators, running at 3,000 r.p.m., and generating alternating current at 6,600 volts, 50 periods, three-phase, as it was found much cheaper in cables to do this, and to convert the current to 220 volts at Britannia Works by motor converters, the existing motors at the Britannia Works all being suitable for this voltage.

The switchboard is of Messrs. Reyrolles' "Ironclad" type, fixed on the floor above the mess-room and lavatory. There is a space between the ceiling of these rooms and the floor above to accommodate all the cable leads to the switchboard. The turbines are mounted on surface condensers fitted with tubes of "Admiralty" mixture, the water here at times being somewhat brackish. The air pumps alongside are of the Brush-Edwards pattern, motor-driven, with an auxiliary pump for delivering the condensate up to a "Lea" recorder.

The turbines are supplied with steam by four Babcock-Wilcox boilers, each evaporating 12,000 lb. at normal load, with 3,580 sq. ft. heating surface and 70 sq. ft. grate area. The working pressure is 200 lb., with superheaters to give 250 deg. F. superheat. The chain grates and drop links are speeded to run at from 6 ft. to 24 ft. per hour. The gases after leaving the boilers go through two economisers, each of 320 pipes, and from these can go direct into the chimney, or through a 55-in. motor-driven fan, which will give a draught of 2½ in., if required. The gases are discharged around the base of the chimney through a grit separator into the chimney. The chimney is 110 ft. in height by 8 ft. internal diameter, and was made this height to allay the fears of the Lord of the Manor.

Coal Handling.—The coal for the boilers is lifted out of the coal cellar or barge by means of a 30-cwt. electric crane with 20 ft. radius, fitted with a 20-cwt. grab, and dropped into a hopper on a platform 42 ft. above; this platform is carried by girders from the front of the boiler-house to four upright stanchions of 12 in. by 6 in. H steel, strongly braced, which stand on top of the suction well and are firmly bolted thereto. The coal is filled from the hopper into a truck holding about 12 cwt., which is run on a tramway over a ferro-concrete coal bin holding about 600 tons; a "Grizly" is fitted between the rails, and the tramway falls about 12 in. in its length, so that the load is easily pulled by a small motor fitted under the platform. After being filled, the truck is pulled over an automatic weighing machine which registers the weight of each truck and the total weight; it then passes on over the bin and tips automatically where required, afterwards being pulled back to be refilled from the hopper. The hopper is arranged on wheels so that if better and larger fuel is any time obtained, a breaker can be installed on the staging. This arrangement was adopted in preference to a conveyer arrangement, as it did not take up any floor space and was considerably cheaper. Each charge of coal to the boiler hoppers is weighed automatically by a simple valve arranged on the shoots. A conveyer could not be arranged to lift from a barge, as the difference between low water and extra flood tide might easily be 18 ft. The crane and grab with tramway truck cost slightly over 1,000*l.*, but one estimate for a conveyer alone cost 2,000*l.*, and the crane and grab were still required.

The coal bin is provided with five electric thermometers which will ring an alarm bell in the manager's office, should the temperature of the coal rise 2 deg. F., but as the coal is constantly drawn from the lower part of the bin, no inconvenience from spontaneous combustion is anticipated. The coal now used is of very inferior quality and of a calorific value of 10,200 British thermal units, containing 26·28 per cent. of absolute ash, 25·01 per cent. volatile matter, 45·26 per cent. fixed carbon, 4·45 per cent. moisture; and the theoretical evaporative power from and at 212 deg. is 10·52 lb.

Ashes.—The ashes are dumped by the dumping grate into a brick-lined ash pan, the bottom of which is fitted with a sliding door acutated by a pinion and rack. This, when open, permits the ashes to fall into a truck in the ash tunnel beneath; and after slaking, the truck is hauled on to a hoist which lifts the truck up and dumps its contents into an ash bin holding 40 tons. The bottom of this bin is fitted with two valves to permit the ashes being dumped either into a barge or cart as may be desired; at present there is locally a good demand for ashes.

Circulating Water.—The water for the circulating pumps is taken from the suction well by a 20-in. cast-iron pipe built into the back wall and fitted with a reflex valve; it goes down to within 2 ft. of the bottom, the bottom length of pipe being considerably bell-mouthed to reduce the speed of entry, and at the lowest tide there is 5 ft. head; provision is made for a second pipe for extension. This pipe is laid in a tunnel 11 ft. 6 in. wide by 7 ft. high under the firing floor of the boiler-house. The floor of the tunnel rises 12 in., and the pipe has only one bend in the whole length; every joint is easily visible and accessible. The return-flow main is laid alongside; the outflow from this goes into the river, north or south of the intake, according to the flow of the tide. The blow-off main and cold-water service main are also fixed in this tunnel, together with two "Wilcox" automatic water elevators, which lift any drain water into the suction well.

Cold Water Service.—The cold water service is pumped up by two 5-in. centrifugal motor-driven pumps into a cast-iron tank holding 6,500 gallons, fixed at the street end of the coal bin. This tank is fitted with a rough sand filter and a floating suction. It supplies water to the evaporator, for washing out service pipes, circulating pump bearings, fan bearing and lavatories.

Boiler Feed Make-up Water.—The feed water for the boilers consists of the condensate from the turbines and make-up feed from a "Caird and Rayner" 20-ton evaporator, supplied with water from the overhead tank. The condensate from the turbines is delivered up to a "Lea" recorder and from there flows by gravity into a hot-well tank holding 6,500 gallons. This hot-well also receives the trap drains from the steam main, the drains from stop valves, the exhaust steam from turbo-feed pumps and evaporator, and its temperature is not less than 160 deg. F. Should the evaporator fail from any cause, there is an automatic ball valve inside the tank which will come into action as soon as the water is lowered to a fixed point. The evaporator is guaranteed to evaporate 1¼ lb. of water per pound of steam; it may not be so economical as a softening plant, but is more cleanly in its working, and does not fill the pipes up with flocculent lime mud; it needs but little attention, once a month for about 2 hours, to clean the outside of the coils. By this means, the boilers are grease-clean and the labour of scaling is avoided; a little lime has to be introduced by giving a percentage of river water occasionally which forms a slight coating and prevents pitting. The river water averages from 14 deg. to 16 deg. of hardness. From the hot-well, the water is fed to the boilers by a "Weir" single-turbo centrifugal pump, running 2,000 r.p.m., and a six-series motor-driven "Pulsometer" centrifugal pump. The feed pipes are so arranged that the water can be fed either direct to the boilers or through the economisers.

The right-hand side of the firing bay is finished temporarily with asbestos sheets, provision being already made for the roof principals of the extension. All through this plant, attention has been given to accessibility, both for repairs and information, gauges, thermometers and recorders being provided as follows:—Draught gauge at chimney; recording thermometer at chimney; thermometers at inlet and outlet of each economiser, giving temperature of inlet and outlet gases

* Paper read before the Institution of Mechanical Engineers, at Lincoln, July 21, 1920.

and water; CO_2 recorder and temperature of furnace recorder ("Uehling") with indicator at boiler fronts; pressure recorder on steam main; superheat thermometer on steam main; gauges showing head on suction and delivery of each air pump; ammeters; vacuum gauges on delivery pipes from condensers; mercury vacuum gauge, temperature of inlet and outlet water, temperature of steam entering condenser, to each turbine; "Lea" recorder integrator; indicating and integrating wattmeters.

Old Electric Station.—This contains four engines (three to work, one as stand-by). In 1913, 8,997 tons of coal were burnt, costing 6,100*l.* In 1913 water at 6*d.* per 1,000 gallons was used, costing 815*l.* In that year 3,000,000 kw.-hours were generated, during 300 days, averaging 12 hours, and in addition two engines were running off the same boilers. The latter were giving a total of 380 h.p., and were using about 24 lb. of steam per horse-power hour, and the boilers evaporating 7½ lb. water per lb. of coal (= 1,980 tons of coal per annum), leaves 7,017 tons used to generate 3,000,000 kw.-hours = 5¼ lb. per kilowatt-hour.

Wages for this station cost 75*l.* per week.

New Station.—During the six winter months from November 1, 1919, to April 30, 1920, there have been generated 1,222,628 kw.-hours, and 1,556 tons 18 cwt. 3 qr. of coal have been burnt, which is equivalent to 2·85 lb. per kilowatt-hour. The staff consists of four men and two women, and their wages amount to 25*l.* per week.

The coal used at the new station is of much inferior quality to that used at the old station, although, at present, it costs more per ton and contains more ash. Further, at the old station, the pumping of the condensing water up the cooling towers and driving the fans took 170 kw. and cost, at ¼*d.* per unit, 1,912*l.* and 815*l.* for water.

All the auxiliaries, namely, fan, stokers, air pumps, lifting crane and haulage motors at the new power station take only 140 amperes at 220 volts, and at ¼*d.* per unit cost 225*l.* per annum. The water supply is taken free from the Trent. At a test taken on March 18 last by Captain H. Riall Sankey, C.B., the steam consumption of the turbines working at full load of 1,500 kw. came out at 12·42 lb. per kilowatt-hour, with 208 lb. steam pressure (gauge) at stop valve, 192 deg. F. superheat, and 0·80 lb. per square inch absolute back pressure.

In daily running the above-named instruments show the following average readings:—

Steam pressure recorder	195 lb. to 200 lb. per sq. in.
Mercury vacuum-gauge on turbine	94·6 per cent. abs. vacuum.
Feed water—	
Hot well	160 deg. F.
Into economiser ...	160 deg. F.
Out of economiser ...	270 deg. F.
Gases from boilers—	
Into economiser ...	480 deg. F.
Out of economiser ...	375 deg. to 380 deg. F.
Into chimney ...	300 deg. F.
Circulation pumps—	
110 amperes, 220 volts.	
Head against 4 to 6 ft. / Suction against 10 to 14 ft.	According to tide.
Air pumps	15 amperes, 220 volts.
CO_2	6 per cent., occasionally 8 per cent.

Draught gauge on fan, 1½ in.; when using an extra fine sample of coal, occasionally 2 in.

Speed of grate has to be varied very frequently to suit the fuel coming down from the bin.

The present load is from 1,200 kw. to 1,420 kw.; voltage and revolutions steady at 6,600 and 3,000.

No figures are available for half-load.

PROPOSED TRACTOR TRIALS IN INDIA.—We read in *The Board of Trade Journal* that the Joint Director of the Agricultural Research Institute of the Government of India, Pusa, Bihar, states that his Department is at present working out the details of a proposal to hold trials on a large scale of agricultural motor-tractors some time next year. It will be necessary to carry out the trials on a large scale in some central place, such as Cawnpore, where workshop and other facilities are available, and it is recognised that the expenditure will be heavy. The proposals which the Authorities in India are working out contemplate an expenditure which may reach a lakh or even two, of rupees, as he is of opinion that the trade will expect assistance in conveying the machines and mechanical staff from the ports to the trial ground.

A SWEDISH OIL-IMPORTING COMPANY.—We read in *Swedish Export* that the great interest shown throughout the world in oil as a means of generating power has found expression in Sweden, shipowning and financial circles co-operating in the formation of a great oil-importing company, having a capital of 8,000,000 kr. The new undertaking is to safeguard the procuring and distribution of crude oil for oil-fired steamships and motorships by the establishment of bunker stations, and for industrial fuel instead of coal. The company has made a preliminary agreement with the owners of extensive oilfields and purifying works on the American continent for a long series of years to come. The company is also to interest itself in fishing and to establish minor depots for local requirements in the fisheries and other industries. Amongst the founders may be mentioned the heads of the largest trans-oceanic ship-owning companies in Sweden, the Transatlantic, Svenska Lloyd and the Broström concern.

CATALOGUES.

Oil Burners.—Messrs. Alldays and Onions, Limited, Birmingham, send a four-page catalogue clearly explaining and illustrating their oil-burning outfits for steam boilers and industrial furnaces generally.

Cultivating Machines.—A considerable range of machines for digging, hoeing, raking, swath turnings, potato digging, &c., is described in a very compact little catalogue issued by the makers, Messrs. Martins Cultivator Company, Limited, Stamford.

Well-Drilling Engines.—Special engines and boilers for drilling oil wells are described in a catalogue from Messrs. Marshall, Sons and Co., Limited, Gainsborough. Everything necessary for this special work is described. The engine and boiler are each complete and ready to put into working position.

Electro-Plating.—A very interesting booklet comes from Messrs. W. Canning and Co., 133, Great Hampton-street, Birmingham, who are makers of plant and materials for electro-plating and polishing. The booklet contains a history of the firm, reports of meetings of the employers and employees and a record of those who served in the war.

Steam Engines.—The steam engine makers are urging the advantage of putting in the most economical forms of steam engines and scrapping the older forms now that coal has risen so much in price. Messrs. Cole, Marchent and Morley, Limited, Bradford, send a four-page circular giving reasons for this change, and also offering central exhaust and tandem compound engines working with very low coal consumptions.

X-Ray Apparatus.—The construction and use of tube stands and couches for X-ray treatment are explained in a catalogue issued by Messrs. Watson and Sons (Electro Medical), Limited, Parker-street, Kingsway, London. Prices are stated for outfits and various separate parts. Particulars are also given of sphere-gap voltmeters for measuring voltages of continuous or intermittent discharges up to 250,000. In these instruments balls are used instead of points.

Agricultural Tractors.—A catalogue of Austin farm tractors which has come to hand from Messrs. Rootes, Limited, Maidstone, contains much explanatory and argumentative matter relating to land-working machinery of great interest to farmers. Figures for wages, paraffin and lubricating oil are worked out per acre ploughed, and finally resolved into the statement that ploughing costs 4*s.* 6*d.* per acre with paraffin engines as compared with 50*s.* per acre for horse ploughs, allowing wages at 1*s.* per hour in both cases.

Centrifugal Pumps.—Messrs. Gwynnes, Limited, Hammersmith, London, W. 6, send an extremely interesting catalogue of centrifugal pumps used for all general purposes including salvage, dock, sewage and gravel and sand pumping. Seven standard sizes of the latter type are listed with outlets ranging from 4 in. to 12 in. in diameter, and these are designed to permit the passage of solid spheres of equal diameter to the bores of the pipes. The catalogue contains some very striking illustrations and much useful information.

Motor Car Accessories.—A very comprehensive catalogue of over 600 pages has been issued by Messrs. Brown Brothers, Limited, Great Eastern-street, London, E.C. 2, containing particulars of practically all supplies for the garage in the way of parts, materials, tools, and even machinery. Everything is illustrated with lists and tables in a clear and convenient fashion, and an idea of its completeness may be gathered from the fact that the index alone occupies eight pages of four columns each. This publication should be extremely useful for garages and workshops.

Centre Punch.—A sensitive centre punch for marking-out quickly and accurately is shown in a leaflet received from Messrs. Burton Griffiths and Co., Limited, Ludgate-square, London, E.C. 4. It can be used for centre punching as well as for all kinds of marking-out work, and an important feature in the design is that there are no springs or internal mechanism liable, to get out of order. With a little practice a series of dots of uniform depth can be made and a line can be followed easily. When worn the point can be renewed at a trifling cost.

Large Gas Engines.—A series of large gas engines made by Messrs. Galloways, Limited, Manchester, is very fully described and illustrated in a special catalogue to hand from that firm. Fourteen sizes are listed of the single tandem type with outputs ranging from 425 brake horse-power to 2,300 brake horse-power, and each size can be supplied of the twin tandem type to give double power. The design is specially adapted for using blast-furnace gas with great economy for driving, blowing engines and electrical generators. The largest cylinders are 55 in. diameter and 55 in. stroke.

Internal Grinding.—The grinding of small holes, say up to 1 in. bore is often desirable and is now a necessity in the case of hardened bushes. For such work grinding wheels down to ¼ in. diameter may have to be used, and the spindle revolution must then be very high in order to obtain the necessary surface speed. Grinding wheels wear very rapidly if they are run at too low a surface speed, depending on the class of wheel. Messrs. A. A. Jones and Shipman, Limited, Leicester, are now producing spindles, and also complete grinding heads, suitable for continuous work at speeds up to 50,000 r.p.m., as well as a range of heavier patterns for grinding holes up to 5 in. in diameter. These are illustrated and briefly described in a small catalogue issued recently.

Pneumatic Conveyor.—Several examples of mechanical equipments for conveying grain, seeds of most kinds, and substances like sugar or small coal are illustrated in a catalogue issued by Messrs. R. Boby, Limited, Bury St. Edmunds. The machines may be mounted on rails for transferring material from ship to shore or barge, or in a special barge for the same purpose, or built into a coasting steamship which would load itself from land or from an ocean steamship and unload at small coast towns or *vice versa*. The grain or other material is drawn through a pipe and passed through a receiver and filter, and then discharged; if desired, a weighing machine may be incorporated in the plant. Capacities of 50 tons per hour and 150 tons per hour are mentioned. Great economy is claimed for usual working distances, and up to about 1,000 ft.

Textile Mill Drives.—A four-page circular issued by the General Electric Company, Limited, 67, Queen Victoria-street, London, E.C., contains some 12 illustrations and a brief explanation of the driving method adopted at Messrs. Fleming, Reid and Co.'s worsted mills near Greenock. An hydraulic turbine supplied from a waterfall in which the flow is 24,000 cub. ft. per minute falling 180 ft., yields 580 h.p., and part of this power is transmitted directly to the shafting on six floors and the remainder to a 125-kw. alternator, rope driving being used in all cases. A number of small motors throughout the building are driven from the alternator and current is also taken from the corporation mains to compensate for the variations in power from the waterfall. The only fault of the circular is the brevity of the text, which might well be expanded in future editions; it is, however, of exceptional interest.

Steam Tractors.—A steam traction engine under 5 tons in weight when empty, is, according to law, a steam tractor. It differs from a steam wagon in being a hauling engine, in having large driving wheels which are advantageous to both road and machine. It does the same work with less concentration of weight on the rear axle, and has some auxiliary powers and resources for use in special difficulties which are not usually provided on steam engines. Some of these advantages are defined in a special catalogue of steam tractors issued by Messrs. Marshall, Sons and Co., Limited, Gainsborough. Two types are dealt with having single and compound cylinders, with steam pressures of, 180 lb. and 200 lb. per square inch respectively. The dimensions are generally the same in both types and both have flywheels with rims suitable for belt driving, in which work their economical brake horse-power is 20. Both have two road speeds of 2½ m.p.h. and 5 m.p.h., and are capable of hauling 8 tons gross load at full speed on the level and up an incline of 1 in 12 at half-speed. Many of these tractors have been in use for some years and, especially for rough varied work, their advantages in comparison with other means of motor road transport should be carefully considered.

THERMOSTATIC METAL.—Thermostatic metal, manufactured by the British Thomson-Houston Company, Limited, in appearance a homogeneous metal, is formed of two metal strips having widely different coefficients of expansion. The two metals are welded together along their entire length and are quite inseparable under normal working conditions. When the duplex strip is subjected to change of temperature, one half will expand more quickly than the other, causing the strip to bend. A single degree of temperature change is said to affect its curvature to a measurable extent, and practically instantaneously. In bending, it exerts a force sufficient for the direct operation of levers, the opening and closing of ventilators, &c. The metal can be cut, stamped or machined. It is supplied in various thicknesses from 0·015 in. to 0·25 in.

THE PURIFICATION OF COMPRESSED GASES.—Though the purity of commercial compressed and liquefied gases interests the chemist more than the engineer, the problem affects the latter also. Moreover, there is but little information concerning the subject to be found in literature. Purification processes in use are critically reviewed by L. Moser and W. Foltz, of the Vienna Technical High School, in the *Zeitschrift für Anorganische Chemie*, vol. cx, pages 125 to 142. Carbon dioxide largely serves as an indifferent gas to replace or to keep out other gases; it is produced by absorbing the coke-oven gas in caustic potash, the bicarbonate obtained being then decomposed by boiling. Any oxygen present is destroyed by passing the CO_2 over glowing copper, or in the wet by passing the gas through chromium chloride or acetate or also through the commercial titanium chloride; the former dry process does not appear to favour the formation of carbon monoxide, as had been suggested. If present in CO_2, this CO is oxidised by heating the gas over asbestos coated with copper oxide. Commercial nitrogen is generally very pure, apart from the rare gases; oxygen (in the nitrogen) is absorbed in the wet by copper wire gauze in ammonia or in the dry by heating the gas with copper and asbestos. In hydrogen when made from water gas, the most troublesome impurity is CO_2, which is objectionable in itself, and also because the CO of the compressed gas attacks corroded steel cylinders under formation of iron carbonyl $Fe(CO)_5$; there may be two other iron carbonyls, in fact. This carbonyl is very difficult to get rid of, because during the purification CO itself is apt to be reformed, and could only be removed by liquid air. Fortunately most compressed hydrogen contains only traces of the carbonyl, but Moser found in the gases of two cylinders 3 per cent. of iron as carbonyl, and he therefore suggests that steel cylinders for hydrogen should be enamelled or lined inside. Commercial chlorine gas, which is now practically all electrolytic, is purified by liquefaction at − 33·6 deg. C.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not Illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in Italics.

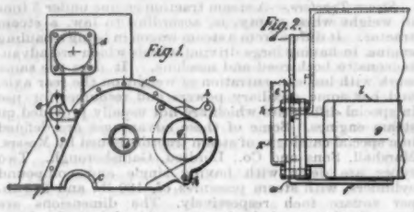
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

GAS ENGINES, PRODUCERS, HOLDERS, &c.

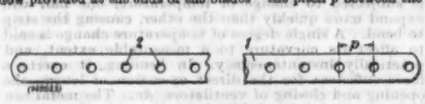
142,711. Crossley Motors, Limited, Manchester, and R. H. Rose, Manchester. Internal-Combustion Engines. (2 *Figs.*) July 18, 1919.—The invention relates to internal-combustion engines. According to the invention, all the faces are cast on, say, the front of the crank-case in one and the same plane, so that they can be machined at one side of the planing or other machine. *a* is the timing gear face; *b* the camshaft end bearing face; *c* the upper part of the crankshaft end bearing face; *d* the water pump and fan face; *e* the water inlet flange face and *f* the face to receive and fit against the bottom half of



the crank-case. When in position the bottom half of the crank-case is secured to the face *f*, and has its end machined level with the faces *a*, *b*, *c*, *d*, *e*, which are all in the one and same plane. The accessory shaft, the centre of which is indicated at *g*, is surrounded by bolts A employed to hold in position the accessory *i* and the timing gear cover *k*. Each bolt A passes through the cover *k*, the crank-case and accessory *i* and draws the latter up against a face *j* prepared to receive it on the near side of the crank-case, and thus great rigidity is insured. (*Accepted May* 19, 1920.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

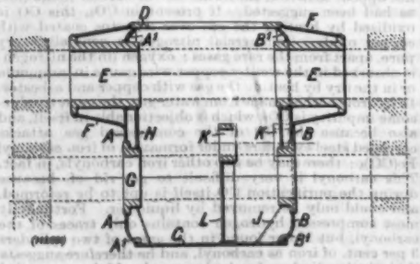
142,623. C. H. Shearer, Liverpool. Hack-Saw Blades. (1 *Fig.*) March 31, 1919.—The invention relates to hack-saw blades, having the ends of the blade softened and provided with holes adapted to engage with pins which form part of the clamping devices on the fixed and adjustable parts of the frame. According to the invention, the hack-saw blade 1 is drilled, during the process of manufacture, with a series of holes 2 extending in line from end to end of the blade, and spaced at suitable intervals along its length. The holes are usually of the same size as those now provided at the ends of the blades the pitch *p* between the



holes may be varied to suit circumstances, but usually this would be about three-quarters of an inch pitch, the holes being, say, three-sixteenths of an inch diameter. In the event of an ordinary blade breaking, it is usually necessary to substitute a new one, often in the middle of a cut, and in event of the teeth of the new blade being wider than those of the one which has broken, it is difficult to follow up the cut, and this often results in the breaking of the new blade also. By the use of the invention therefore, this risk is practically eliminated. When a blade, constructed in accordance with the invention, breaks, there will be a hole already drilled near the point of fracture; the blade is therefore at once available for use again, as it is only necessary to snip or grind off the fractured edge, should it extend too far beyond the hole to permit of its being snugly housed in the frame or holder, after which the blade can be replaced in the holder. (*Accepted May* 19, 1920.)

MOTOR ROAD VEHICLES.

142,691. T. Broadbent, East Molesey. Gear-Box. (3 *Figs.*) June 12, 1919.—A gear-box made according to the invention comprises two end members of a contour conforming to the cross-section of the box and having upstanding flanges



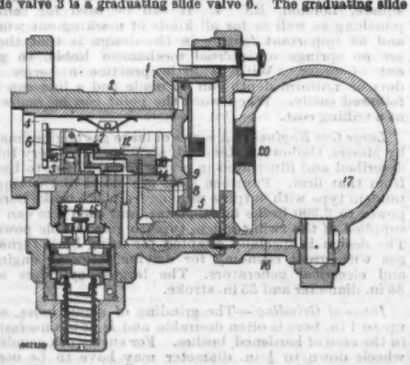
about their peripheries, and a central member of plate bent to the contour and attached to the flanges of the end members by welding. The central member does not extend entirely around the end members but finishes at a flat to receive the box cover. A flange of material, heavy enough to take studs or bolts to hold the cover in place, is welded upon the end members and to the edges of the central member at the flat. Two end members A, B, of contour conforming to the cross-section of the box have their peripheries inturned towards one another to form flanges A1, B1, by which they are attached to a central member C of plate bent to their contour, which, however, does not extend entirely around the end members, but finishes at their upper edges, and with those edges is adapted to receive a flange D secured by welding and sufficiently heavy to take studs by which a cover is secured. Sleeves E carrying the primary shaft bearings, are welded into apertures in the end plates A, B, and are supported at their outer ends by cone pieces F, the truncated apices of which are welded to the sleeves while the bases are welded to the end plates. Similar sleeves G carry the layshaft bearings, and these sleeves are welded into apertures in the end plates A, B, and supported by dished stools H extending between them and the sleeves E, and by bracket plates J extending between them and the bottom of the box. Bearings for a reverse shaft are supported in sleeves K, the one welded into an aperture in the end plate B, the other supported on a flanged stool L from the bottom and side of the box. (*Accepted May* 19, 1920.)

142,605. A. Rynar, London, and W. B. Milson, Eltham. Springs for Road Vehicles. (2 *Figs.*) March 17, 1919.—The invention relates to the type of spring suspension of vehicles in which centrally-supported laminar springs are pivotally connected at each end to a spring-controlled piston working in a chamber attached to the vehicle chassis and capable of slight rotational movement to prevent torsional strain of the spring. According to the invention, the front end of the spring is pinned or journalled within a bifurcated piston-shaped piece which is housed within a casting attached to the front extension of the underframe. The front end of the spring *a* is pivoted by the pin *b* between the jaws *c* of the bifurcated piston-shaped piece *d*, such jaws being formed by slotting the piston-shaped piece; or the end of the spring may be mounted or pivoted within the piston-shaped piece after the manner in which the connecting rod of an internal-combustion engine is connected to the piston; in this case the piston-shaped piece *d* is hollowed out. The piston-shaped piece is housed in a front casting *e*, which casting is

fixed upon the front boom *x* of the vehicle and is bored for the reception of said piece in prolongation of the length of the spring *a*. The casting *e* is provided with a partition or diaphragm *f*, which is preferably integral therewith. The said piston-piece *d* is furnished with an axial stem *g* which passes through a flanged bush *h* fixed in the diaphragm; such stem terminates in a suitable locknut *i*, a resilient or other washer intervening between the rear side of the diaphragm and the front face of the piston *d*. The front end of the spring is thus housed in such a manner as to permit slight rotation thereof together with the piston. The rear end of the spring is housed in like manner within a casting *k*, which is attached to a convenient member of the vehicle body, but the axial bore of such casting in rear of the diaphragm *f* and the piston stem *g* are sufficiently prolonged to admit of the insertion of a volute or other spring surrounding such stem, a washer intervening between such spring and the locknut *i*. The other ends of the castings *e* and *k* are closed each by a dustproof cover or cap *m*, which are secured by screwing. The central portion of the spring *a* rests upon a member *n* of the vehicle supported upon the leading wheels. (*Accepted May* 19, 1920.)

RAILWAYS AND TRAMWAYS.

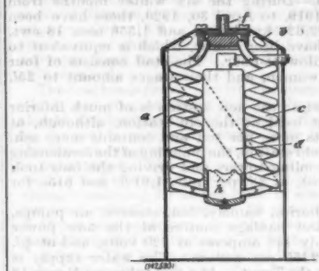
142,250. J. W. Cloud, London. Braking Apparatus. (1 *Fig.*) March 20, 1919.—The invention relates to the triple-valve arrangements for automatic air brakes, in which the triple valve is provided with a bulb or closed receptacle for the special purpose of receiving fluid under pressure which is arranged to be released from the train pipe to effect an application of the brakes. The triple valve comprises a triple valve piston 1 mounted in the casing 2 and adapted to operate a main slide valve 3 in the usual manner. The movement of the triple valve piston 1 from its release position, shown in the drawing, to its application position being effected by the auxiliary reservoir pressure obtaining in the valve chamber 4 acting in opposition to the reduced train-pipe pressure obtaining in the chamber 5. Mounted on the main slide valve 3 is a graduating slide valve 6. The graduating slide



valve 6 is, in addition to the usual ports and cavities, provided with an L-shaped cavity 7 adapted, when the triple valve piston 1 is moved towards its application position due to the reduction in train pipe pressure, but prior to the movement of the main slide valve 3, to establish the following communication: From the passage 8 leading to the train pipe, through a port 9, a passage 10 communicating therewith and formed in the main slide valve 3, a passage 12 shown in dotted lines, the cavity 7, passage 13 shown in full lines, cavity 14 and a passage 15 communicating by means of a passage 16 with an exhaust receptacle or bulb 17, another opening 20 in which is closed by a screw-threaded plug. The fluid under pressure contained in the train pipe is thus, by the initial movement of the triple valve piston 1, vented to the exhaust bulb 17, with the result that the reduction in train-pipe pressure is accelerated and causes a rapid response of the triple valve as regards its movement to application position. The exhaust bulb 17 in the release position of the triple valve shown in the drawing is arranged to be in communication in the usual way with the atmosphere through the passages 16, 15, cavity 14, passage 13, cavity 7, and a passage 18 leading to a port 19, which is in communication with the atmosphere. (*Accepted May* 12, 1920.)

STEAM ENGINES, PRODUCERS, HOLDERS, &c.

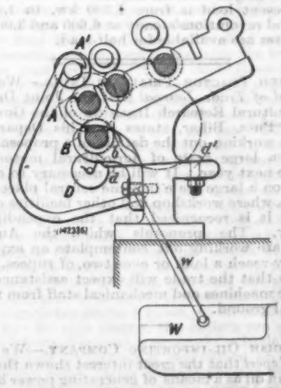
142,580. A. Valente, London, M. Curzon, London, and S. Curzon, London. Steam Generators. (3 *Figs.*) February 22, 1919.—The invention relates to generators for steam of the flash or semi-flash type. A construction of boiler under the present invention comprises a shell *a*, having outlets *b* in the crown thereof, for the spent products of combustion. At the base of the said shell is located a controlled source of heat, for example, a petrol, benzol or paraffin burner. A plurality of vertically arranged coiled tubes *c* is arranged within the shell *a* and so to surround a drum *d*, this drum being substantially of the same length as that of the tubes. Each tube *c* is independent of any other tube. The tubes at their upper ends are connected to a feed supply pipe *f* whereby a gravity circulation of the water in each coiled tube takes place. The tubes at their lower ends communicate with the drum *d* near to the lower end thereof, so



that steam generated in the tubes passes therefrom to the drum, ascends the interior of the drum and passes to the engine cylinder from the upper end thereof. That portion of the combustion gases passing up to the outlet medially of the battery of tubes impinges on the drum, and thus transfers a further portion of the heat units to the steam, whereby water spray carried over with the steam from the tubes to the drum is generated into steam, and further the volume of steam in the drum has a high dryness factor imparted thereto. Any water spray that may accumulate in the drum will fall to the bottom end thereof and remain in a state of relative quiescence, until drawn off through the medium of a plug *m*. The steam drum *d* may have baffle plates A located therein, these plates functioning as a separator or dryer to throw the water spray to the lower end of the drum. (*Accepted May* 19, 1920.)

TEXTILE MACHINERY.

142,336. R. Stott, Jun., Rochdale. Spinning Frames. (2 *Figs.*) June 10, 1919.—The invention relates to the arrangement of the drawing and clearer rollers of spinning frames, such as ring frames and mules. It consists in the particular disposition of an intermediate roller interposed below the bottom front drawing roller, and between it and the clearer, so placed that the end of yarn cannot touch it until it breaks, and running at a greater surface speed than the drawing roller, to draw out and attenuate the broken end for piecing. Below the front bottom drawing roller A, a wiper roller B is mounted, and rotating at a greater speed than, and in the same direction as, the drawing roller A. The wiper roller B is out of contact with the drawing roller A, and so placed as not to contact with the yarn until broken, but close enough to prevent any broken end lapping upon the drawing roller A. A clearer roller D, mounted upon spring supports *d*, is placed below the wiper roller B to rotate in surface contact with it, the rollers B and D thus rotating at a



higher speed than the drawing rollers A and A1. The spring supports *d* for the clearer roller D are affixed to lugs *d1* projecting laterally and rearwardly from the roller stands. The wiper roller B is carried in brackets *b* preferably bolted to the roller stand. The drawing rollers A and A1 are weighted by weights W suspended on weight wires *w* depending from the roller journals. In operation, should an end break, the wiper roller B prevents it lapping upon the bottom drawing roller A, and carries it down to the nip between the wiper roller B and clearer roller D, with the result that it is taken up and lapped upon the clearer roller D. This provides a convenient length of the yarn extending between the nip of the rollers A, A1, and the nip of the rollers B and D, which can be easily taken hold of by the workman for the purpose of piecing the broken end. Moreover, as the rollers B and D are rotating at a faster speed than the rollers A and A1 the yarn is drawn out or attenuated somewhat, thereby facilitating the piecing and preventing a thick or lumpy piecing. (*Accepted May* 12, 1920.)